

Radiological Health Data and Reports

VOLUME 8, NUMBER 3

MARCH 1967

(Pages 135-190)



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service



RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 3 March 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

REPORTS

	Page
Radiation Hazards in Uranium Mines ----- <i>D. A. Holaday</i>	135

DATA

SECTION I. MILK AND FOOD -----	139
National and International Milk Surveillance -----	140
1. Pasteurized Milk Network, November 1966, <i>PHS</i> ..	140
2. Canadian Milk Network, November 1966 -----	145
3. Pan American Milk Sampling Program, November 1966, <i>PAHO</i> and <i>PHS</i> -----	146
4. Radiostrontium in Milk, January-June 1966, <i>HASL</i>	147
State Milk Surveillance Activities -----	148
1. California Milk Network, July-September 1966 ---	148
2. Oregon Milk Network, July-September 1966 -----	150
3. Washington Milk Network, July-September 1966 --	151
Food and Diet Surveillance Activities -----	153
1. Cesium-137 in Tri-City Diets, 1965, <i>HASL</i> -----	154

CONTENTS—continued

	Page
SECTION II. WATER	158
Gross Radioactivity in Surface Waters of the United States, September 1966, <i>FWPCA</i>	159
SECTION III. AIR AND DEPOSITION	162
Radioactivity in Airborne Particulates and Precipitation	162
1. Radiation Surveillance Network, November 1966, <i>PHS</i>	162
2. Canadian Air and Precipitation Monitoring Program, November 1966	166
3. Mexican Air Monitoring Program, November 1966	167
4. Pan American Air Sampling Program, November 1966, <i>PAHO</i> and <i>PHS</i>	168
5. Fallout in the United States and other areas, <i>HASL</i> January-June 1966	169
SECTION IV. OTHER DATA	173
Strontium-90 in Human Bone, April-June 1966, <i>PHS</i>	173
Environmental Levels of Radioactivity at Atomic Energy Commission Installations	176
1. Argonne National Laboratory, January-June 1966	177
2. Atomics International, January-June 1966	182
3. Feed Materials Production Facilities, January-June 1966	184
4. National Reactor Testing Station, January-June 1966	187
SECTION V. TECHNICAL NOTES	190
Reported Nuclear Detonations, February 1966	190
Synopses	iii
Erratum	iii
Symbols, Units, and Equivalents	Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
National Center for Radiological Health
Donald L. Snow, Chief

BOARD OF EDITORIAL ADVISORS

Dr. Ronald G. Menzel
Department of Agriculture
Dr. Wilfrid B. Mann
Department of Commerce
Robert E. Simpson
Food & Drug Administration, DHEW
John A. Harris
Atomic Energy Commission

STAFF

Managing Editor Samuel Wieder
Assistant Managing Editor Charles F. Coyle
Senior Technical Editor Richard D. Grundy
Technical Editors Kurt L. Feldmann
Marvin Rosenstein
Richard Wromble
Illustrator Marylee Hill

Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Maryland 20852.

For further information on any subject reported in this issue, readers are referred to the contributors indicated in article headings.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • National Center for Radiological Health

RADIATION HAZARDS IN URANIUM MINES

D. A. Holaday¹

A review of health studies of U.S. uranium miners is presented. The primary radiation hazard in uranium mines is alpha radiation which is delivered to the lungs by radon-222 and its short-lived daughters. The appearance of lung cancer among uranium miners has been studied and was found to be excessive. The cell-type distribution of these cancers of uranium miners is different from that of the general population. Calculation of radiation dosage to the lungs of miners is difficult.

General dilution ventilation is the primary method of controlling the radiation hazard, but it has limitations. Radiation exposure of uranium miners has gradually been reduced.

Sixteen years have elapsed since a study of radiation hazards in uranium mines was undertaken jointly by the U.S. Public Health Service and the State health departments of Colorado, Arizona, New Mexico, and Utah. Many different individuals and groups have contributed their efforts to this project, and a great deal of information has been accumulated which demonstrates that uranium miners have had the most significant exposures to radiation of any industrial group in this country.

In 1950 about 500 men were engaged in mining uranium ores in the Colorado Plateau, mostly in small underground workings, with an average production of about 1 ton per man-day. The employment peak was reached in 1960 when about 5,800 underground miners were employed. Approximately 2,800 miners are now working and are producing 3 tons of ore per man-day. The Public Health Service Occupational Health Field Station now has on file environmental data on over 1,200 different mining operations, but an unknown addi-

tional number of operations were never surveyed. During the third quarter of 1965, environmental samples were obtained in 229 mines, which is somewhat greater than the number of mines working at any one time. A number of mines opened or closed during this period, but the number of active mines remained fairly constant throughout the year. This pattern of operation, which has prevailed during the life of the industry, has complicated attempts to control the hazards to which the miners are exposed, and to maintain occupational and environmental records.

Since 1950, many thousands of men have been exposed to the radiation hazard in uranium mines created by radon-222 and its short-lived daughters. While the environmental data obtained in the early years of the study are indeed sparse, consisting of one survey per year at best in most of the mines, it is possible to make estimates of the atmospheric concentrations of radon-222 and its daughters to which the men were exposed. Table 1 presents two such estimates.

These numbers can be meaningful when compared with levels that were found in several studies of European mines. Since only radon-222

¹ Mr. Holaday is chief of the Occupational Health Field Station, National Center for Urban and Industrial Health, Public Health Service, Salt Lake City, Utah 84113.

Table 1. Estimates of exposures to various environmental levels of radon-222 and its daughters in uranium mines, 1952 and 1957

1952		1957	
Multiple of working level ^a	Percent of men affected ^b	Multiple of working level ^a	Percent of men affected ^c
<0.5.....	15.8	<0.5	8.2
0.5-2.5.....	16.1	0.5-1.9	24.3
2.5-10.0.....	23.4	2.0-9.9	44.2
>10.0.....	44.7	>10.0	23.3

^a 1.3×10^5 MeV of potential alpha-particle energy per liter of air

^b Total of 733 men

^c Total of 1,890 men

concentrations were measured in the European mines, it is necessary to make assumptions concerning the equilibrium ratios between radon and its daughters that may have prevailed in the mines, to estimate the "working levels" of radon daughters that existed. Using these assumptions, it appears that the European miners were exposed to radon-daughter concentrations of from 10 to 180 times the working level. (One working level is equivalent to 100 pCi of radon-222 at equilibrium with its daughters per liter of air.) A large proportion of American uranium miners worked in situations similar to those in Europe.

The effects of these exposures as measured by the incidence of lung cancer have been analyzed in detail in a report of a mortality study of 3,415 miners, by Wagoner *et al.* (1). By December 31, 1963, 249 deaths had occurred in this group, of which 30 were caused by lung cancer. The data showed that lung cancer was related to the total cumulative exposure to radon-222 and its daughters and that the age-standardized incidence rate increased from 3.10 cases per year per 10,000 men in the lowest cumulative-exposure group (<120 WLM)² to 116.12 cases per year per 10,000 men in the highest cumulative-exposure group (>3,720 WLM). An etiological association appears between the concentration of radon-222 and its daughters, length of exposure, and lung cancer.

Conclusions concerning the degree of increased risk of lung cancer in uranium miners can only be speculative at present. For most of the study group, it was found that the time

² WLM, working level months, represents cumulative radiation exposure in uranium mines.

from first exposure to the appearance of lung cancer has been shorter than the median time for development of lung cancer (in uranium miners this appears to be about 17 years). We now know that at least 50 cases of lung cancer have occurred in this group of miners, and it is certain that additional cases will develop. The situation is also complicated by the fact that the proportion of miners dying in industrial accidents is much larger than it is in the general industrial population. However, it can be stated that the number of deaths from lung cancer in the members of the study group has greatly exceeded the expected number and that the incidence has increased with continuing exposure to radon-222 and its daughters.

A study of cancer-cell types reported by Saccomanno and Archer showed some interesting differences between uranium miners and a matched age-smoking-history control group of nonminers (2).³ These findings are summarized in table 2.

Table 2. Comparison of cancer-cell types in uranium miners and a matched control group of nonminers

Cancer-cell type	Age-smoking matched control group (percent)	1 to 360 WLM ^a (percent)	361 to 1,200 WLM ^a (percent)	>1,200 WLM ^a (percent)
Epidermoid.....	62.1	61.5	42.1	15.8
Oat cell, round cell, polygonal cell.....	17.6	38.5	47.3	78.9
Large cell (undifferentiated).....	5.9	0	0	0
Adenocarcinoma, combined adeno-epidermoid, alveolar cell.....	13.7	0	10.6	5.3
Total cases.....	51	13	19	19

^a WLM, working level months, represents cumulative radiation exposure in uranium mines.

The data showed that the fraction of oat-cell, round cell, and polygonal cell cancers increased with continuing exposure to radon daughters. The clinical record of cancer cases in uranium miners also showed that the disease is highly malignant and progresses rapidly. The average time from diagnosis to death is 2.5 months.

The radioactive portion of the aerosols to which uranium miners are exposed is formed by the decay of radon-222 and its daughters in the mine atmosphere. Radon-222 and its

³ Each uranium miner was matched with a non-uranium miner. Pairs were matched as closely as possible for age and smoking history.

daughter products thus exist initially as individual atoms which diffuse rapidly and become attached to the first surface they encounter. Since most dust particles in mine air are less than 5 microns in diameter, essentially all of the radon-222 and its daughters are either attached to respirable particulates or exist as free atoms. Studies in mines have shown that this condition does indeed exist, and that the fraction of activity present as free atoms varies widely, depending on mine conditions (3). It is difficult to estimate radiation doses to the lung because the fraction deposited and the sites of deposition of the radon-222 and its daughters are greatly influenced by particle size and other factors.

Several lung models of varying degrees of complexity have been used to calculate the possible lung radiation absorbed dose that might be received by a miner working in an atmosphere of defined composition. The most detailed study of lung models was made by Altshuler *et al.*, who considered factors such as the site of deposition of radon daughters in the lung, the rate of clearance from the lung, and the thickness of the mucus layer in making calculations (4). These authors estimated that a miner exposed to a carefully defined atmosphere containing two-thirds of a working level of radon daughters⁴ would receive an effective absorbed dose to the segmental bronchi of 24 rads per year from mouth breathing, or 13 rads per year from nose breathing. Such studies are of great assistance in understanding the interaction of the many factors which affect the absorbed dose of radiation delivered to lung tissue, as they point out areas which require investigation. It must be kept in mind, however, that they are based on many assumptions and are valid only if the actual conditions are in accord with those which were assumed to exist. Unfortunately, it is probable that in many instances the assumptions do not agree with the actual conditions. In addition to the factors that affect the composition of the radioactive aerosol, lung clearance mechanisms are known to be altered by

many air pollutants. Ciliated cells may be injured and lose their function, thereby permitting the accumulation of particles in localized areas of the bronchi with resultant changes in viscosity and thickness of the mucus layer. Pathological studies of the lungs of uranium miners have shown that there are many areas showing dysplasia, which may be caused by radiation or other air contaminants, or by a combination of all factors. Therefore, it is possible for two men working in the same atmosphere to receive widely different effective absorbed doses of radiation.⁴

The problem of controlling the exposures of uranium miners to radon-222 and its daughters is different from the problem that exists in other parts of the nuclear energy industry. In most industrial situations, the sources of atmospheric contamination are limited in area, but in uranium mines the entire operation can be, and usually is, a source. Industrial situations are relatively constant, while in these mines the conditions change daily as new areas are opened and old workings are abandoned. Controls that are effective for one industrial operation are usually effective for a similar operation, but there is no "typical" uranium mine. These factors make the design and maintenance of control procedures a very difficult task.

As the entire area of a uranium mine is a source of radon-222, general dilution ventilation has been the method used to reduce the atmospheric concentrations of radon-222 and its daughters, and the general principles involved have been pointed out by Harris and Bales (5) and by Kusnetz (6). Examination of these theoretical considerations and experience shows limitations in the effectiveness of general ventilation for reduction of atmospheric concentrations of radon daughters. In a limited series of measurements in uranium mines, it was found that radon emanation rates varied from 0.5 μCi per minute per 1,000 cubic feet of mine volume to 35 μCi per minute per 1,000 cubic feet of mine volume, which means that the air ventilation required to reduce the concentrations of radon-222 and its daughters to any selected level would vary by a factor of about 8 (5). Engineering and economic requirements place limitations on

⁴ The defined atmosphere contains 100 pCi of radon-222/liter and 200 pCi of total daughters per liter. The daughter concentrations are: polonium-218, 94 pCi/liter; lead-214, 62 pCi/liter; and bismuth-214, 44 pCi/liter. Forty percent of the activity is on particles less than 0.1 micron.

the quantities of air that can be moved in air courses, and physiological considerations limit the velocity of air currents in which men can work. Where large areas of high-grade ore are exposed, it may not be feasible to control exposure to radon daughters by dilution ventilation alone. However, the industry has been gaining experience and is now achieving levels of control that 5 years ago were considered by many to be unattainable. Table 3, which shows conditions in the third quarter of 1965, demonstrates the improvements that have been made.

Table 3. Estimates of environmental levels of radon-222 and its daughters in uranium mines, third quarter 1965

Multiple of working level	Percent of men affected ^a
<1	22
1-2.9	59
3-4.9	14
5-10	4
>10	1

^a Total of 2,342

Maintenance of mine ventilation is a constant effort. Air doors and stoppings become defective and must be repaired. Fans and duct-work require replacement, and an educational campaign must be carried on to insure that the miners will use the ventilation that is provided. During the winter, this may be the most difficult part of the entire operation. Occasional high exposures will continue to occur because of mechanical or human failure, and it is unrealistic to expect that all working areas of any mine will always be in a satisfactory condition. Experiments on the use of water sprays, overpressurization of working areas, and filtration of air have been reported, but none of these procedures has been widely used to date (7,8).

The mining of uranium ores in the United States has resulted in exposing many thousands of men to dangerous amounts of radon-222 and its daughters. These exposures have caused an increased incidence of lung cancer in the miners and this increase is correlated with cumulative exposure to these elements. Efforts to control such exposures by State agencies and mine operators have improved conditions markedly, but much remains to be done to insure that radiation hazards in this segment of the nuclear energy industry are reduced to acceptable levels.

REFERENCES

- (1) WAGONER, J. K., V. E. ARCHER, F. E. LUNDIN, D. A. HOLADAY, and J. W. LLOYD. Radiation as the cause of lung cancer among uranium miners. *New England J Med* 273:181-188 (July 22, 1965).
- (2) SACCOMANNO, G., V. E. ARCHER, R. P. SAUNDERS, L. A. JAMES, and P. A. BECKLER. Lung cancer of uranium miners on the Colorado Plateau. *Health Physics* 10:1195-1201 (December 1964).
- (3) CRAFT, B. F., J. E. OSER, F. W. NORRIS, and R. E. KONZEN. A method for determining relative amounts of combined and uncombined radon daughter activity in underground uranium mines. *Amer Indust Hyg Ass J* 27:154-159 (March-April 1966).
- (4) ALTSHULER, B., N. NELSON, and M. KUSCHNER. Estimation of lung tissue dose from inhalation of radon and daughters. *Health Physics* 10:1137-1161 (December 1964).
- (5) HARRIS, R. L., and R. E. BALES. Uranium-mine ventilation for control of radon and its daughter products. Conference on Radiological Health and Safety in Mining and Milling of Nuclear Materials, I.A.E.A., Vienna, Austria, 2:49-60 (1963).
- (6) KUSNETZ, H. L. Measurement of radon and radon-daughter products in mines. Conference on Radiological Health and Safety in Mining and Milling of Nuclear Materials, I.A.E.A., Vienna, Austria, 2:37-48 (1963).
- (7) COLEMAN, R. D., H. L. KUSNETZ, P. F. WOOLRICH, and D. A. HOLADAY. *Amer Indust Hyg Ass J Quar* 17:405 (1956).
- (8) SCHROEDER, D. L., R. D. EVANS, and H. W. KRANER. Society of Mechanical Engineers Transactions (September 1966).

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. The total diet is the most direct measure of intake of radionuclides; however, since specific dietary data are not readily available, indicator foods may be used to estimate radionuclide intake. As fresh milk is: (1) consumed by a large segment of the U.S. population; (2) contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet; and (3) is the major source of dietary intake of short-lived radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups, combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming there is continuous exposure from intake by the population at large (1-3). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of

exposure (3). Additional guidelines are provided by the FRC Protective Action Guides (4) and by the International Commission of Radiological Protection (5,6).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

- (1) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).
- (2) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).
- (3) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).
- (4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).
- (5) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2, Pergamon Press, New York, N.Y. (1959).
- (6) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press, New York, N.Y. (1965).

NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, vari-

ous national and international organizations routinely monitor radionuclide levels in milk.

1. Pasteurized Milk Network November 1966

*National Center for Radiological Health and
National Center for Urban and Industrial
Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State, the

Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (1).

The results for November 1966 and third quarter of 1966 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. When radionuclide values were below minimum detectable concentrations (1), averages were calculated using one-half the minimum detectable value; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were

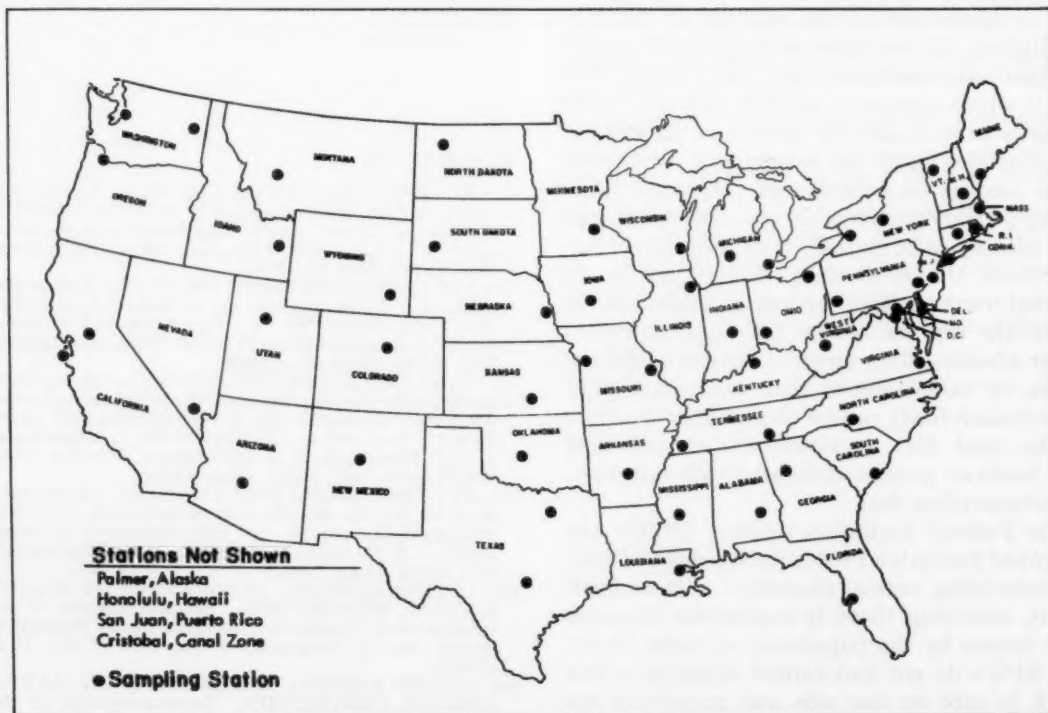


Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of radionuclides in pasteurized milk for the third quarter and November 1966

Sampling location		Concentration, pCi/liter									
		Strontium-90		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Third quarter 1966	November 1966 *	Third quarter 1966	November 1966	Third quarter 1966	November 1966	Third quarter 1966	November 1966	Third quarter 1966	November 1966
Ala:	Montgomery	<5	NA	12	12	0	0	20	15	0	0
Alaska:	Palmer	<5	<5	11	16	0	0	30	25	0	0
Ariz:	Phoenix	<5	<5	3	2	10	0	10	10	0	0
Ark:	Little Rock	5	NA	24	26	0	0	25	20	0	0
Calif:	Sacramento	<5	<5	4	4	0	0	10	10	0	0
	San Francisco	<5	5	4	3	0	0	15	10	0	0
C.Z:	Cristobal	<5	NA	4	7	0	0	15	25	0	0
Colo:	Denver	<5	<5	7	10	0	0	15	15	0	0
Conn:	Hartford	<5	<5	11	9	0	0	30	20	0	0
Del:	Wilmington	<5	<5	12	11	0	0	20	20	0	0
D.C.:	Washington	<5	NA	11	11	0	0	15	15	0	0
Fla:	Tampa	<5	NA	10	11	0	0	135	90	0	0
Ga:	Atlanta	5	NA	19	15	0	0	35	25	0	0
Hawaii:	Honolulu	<5	<5	4	4	0	0	20	20	0	0
Idaho:	Idaho Falls	<5	<5	10	10	0	10	20	15	0	0
Ill:	Chicago	<5	<5	8	9	0	0	20	15	0	0
Ind:	Indianapolis	<5	<5	10	10	0	10	15	15	0	0
Iowa:	Des Moines	<5	<5	12	10	0	0	20	15	0	0
Kans:	Wichita	<5	<5	11	11	0	0	10	10	0	0
Ky:	Louisville	<5	NA	16	14	0	0	10	10	0	0
La:	New Orleans	<5	<5	32	27	0	0	55	30	0	0
Maine:	Portland	<5	<5	14	14	0	0	50	45	0	0
Md:	Baltimore	<5	NA	12	11	0	10	20	10	0	0
Mass:	Boston	<5	<5	15	13	0	0	45	35	0	0
Mich:	Detroit	<5	<5	9	9	0	0	20	15	0	0
	Grand Rapids	<5	<5	12	11	0	0	25	25	0	0
Minn:	Minneapolis	<5	<5	17	17	0	0	25	15	0	0
Miss:	Jackson	<5	NA	20	17	0	0	25	15	0	0
Mo:	Kansas City	<5	<5	13	11	0	0	10	10	0	0
	St. Louis	5	<5	15	12	0	0	20	15	0	10
Mont:	Helena	<5	<5	10	10	0	0	25	20	0	0
Nebr:	Omaha	<5	<5	11	12	0	0	15	10	0	0
Nev:	Las Vegas	<5	<5	4	3	0	0	10	10	0	0
N.H:	Manchester	<5	<5	18	15	0	0	75	50	0	0
N.J:	Trenton	<5	<5	11	10	0	0	20	20	0	0
N. Mex:	Albuquerque	<5	<5	7	5	0	0	10	5	0	0
N.Y:	Buffalo	<5	<5	10	9	0	0	25	20	0	0
	New York City	<5	<5	14	13	0	0	30	25	0	0
	Syracuse	<5	<5	10	9	0	0	25	20	0	0
N.C:	Charlotte	<5	NA	20	21	0	0	25	20	0	0
N. Dak:	Minot	<5	<5	21	25	0	0	25	20	0	0
Ohio:	Cincinnati	<5	<5	11	10	0	0	15	10	0	0
	Cleveland	<5	<5	11	11	0	0	20	20	0	0
Okla:	Oklahoma City	<5	NA	12	9	0	0	10	10	0	0
Ore:	Portland	<5	<5	11	11	0	0	30	20	0	0
Pa:	Philadelphia	<5	<5	11	10	0	0	20	15	0	0
	Pittsburgh	<5	<5	15	14	0	10	25	20	0	0
P.R:	San Juan	<5	NA	7	7	0	0	20	15	0	0
R.I:	Providence	<5	<5	15	12	0	0	35	25	0	0
S.C:	Charleston	<5	<5	20	19	0	0	50	30	0	0
S. Dak:	Rapid City	<5	<5	14	16	0	0	15	20	0	0
Tenn:	Chattanooga	<5	NA	20	17	0	0	25	15	0	0
	Memphis	<5	NA	16	14	0	0	10	10	0	0
Tex:	Austin	<5	NA	5	5	0	20	10	<5	0	0
	Dallas	<5	NA	11	10	0	0	10	10	0	0
Utah:	Salt Lake City	<5	<5	9	9	0	0	15	15	0	0
Vt:	Burlington	<5	<5	12	11	0	0	35	25	0	0
Va:	Norfolk	<5	NA	16	13	0	0	20	10	0	0
Wash:	Seattle	<5	<5	18	18	0	0	55	35	0	0
	Spokane	<5	<5	12	13	0	0	30	35	0	0
W. Va:	Charleston	<5	NA	14	16	0	0	15	15	0	0
Wis:	Milwaukee	<5	<5	8	9	0	0	20	15	0	0
Wyo:	Laramie	<5	<5	9	5	0	0	15	15	0	0
Network average		<5	<5	12.3	11.7	0	0	25	20	0	0

NA, no analysis.

Table 2. Iodine-131 concentrations, pCi/liter,

Station location		November 1966														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ala:	Montgomery			<10							11					
Alaska:	Palmer								<10							<10
Aris:	Phoenix			<10							<10					
Ark:	Little Rock							<10							24	
Calif:	Sacramento				<10					<10						
	San Francisco			<10							<10					
C.Z:	Cristobal							<10							<10	
Colo:	Denver			<10								<10				
Conn:	Hartford				<10							<10				
Del:	Wilmington			<10							<10					
D.C:	Washington				<10						<10					
Fla:	Tampa			<10					<10							
Ga:	Atlanta		<10							<10						
Hawaii:	Honolulu	<10						<10								<10
Idaho:	Idaho Falls							<10							33	
Ill:	Chicago	<10							<10							13
Ind:	Indianapolis							<10							26	
Iowa:	Des Moines			<10							<10					
Kans:	Wichita							<10						<10		
Ky:	Louisville	<10							<10							<10
La:	New Orleans			<10						<10						
Maine:	Portland															
Md:	Baltimore	<10						<10		12					<10	31
Mass:	Boston	<10							<10							<10
Mich:	Detroit	<10							11							12
	Grand Rapids							<10							13	
Minn:	Minneapolis	12							<10							13
Miss:	Jackson							<10							16	
Mo:	Kansas City				<10						37	<10				
	St. Louis				14											
Mont:	Helena		<10					<10								<10
Nebr:	Omaha				<10							<10				
Nev:	Las Vegas				<10					<10					<10	
N.H:	Manchester	<10			<10				<10							<10
N.J:	Trenton	<10						<10								<10
N. Mex:	Albuquerque	<10						<10							<10	
N.Y:	Buffalo				<10											
	New York							<10							21	
	Syracuse		<10						<10							
N.C:	Charlotte							<10								<10
N. Dak:	Minot							<10							11	
Ohio:	Cincinnati							<10							20	
	Cleveland				<10						16					
Okla:	Oklahoma City	<10								<10					14	
Ore:	Portland				<10										<10	
Pa:	Philadelphia				<10											
	Pittsburgh	<10						<10								24
P.R:	San Juan							<10							<10	
R.I:	Providence	<10						<10								18
S.C:	Charleston	<10						<10								<10
S. Dak:	Rapid City							<10							<10	
Tenn:	Chattanooga			<10						<10						
	Memphis			<10												
Tex:	Austin				<10					<10						
	Dallas							<10							33	
Utah:	Salt Lake City							<10							<10	
Vt:	Burlington	<10							<10						<10	
Va:	Norfolk				<10							<10				
Wash:	Seattle			<10							<10					<10
	Spokane	<10									<10					
W. Va:	Charleston					<10						12				
Wis:	Milwaukee											<10				
Wyo:	Laramie		<10							<10						

in individual milk samples, November 1966

November 1966—Continued															Station location
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
	11						<10						<10		Ala: Montgomery.
	<10					<10			<10						Alaska: Palmer.
		<10			10								<10		Ariz: Phoenix.
	<10						<10						<10		Ark: Little Rock.
															Calif: Sacramento.
															San Francisco.
					11								<10		C.Z: Cristobal.
	<10	<10						<10	<10						Colo: Denver.
							15								Conn: Hartford.
	12								<10						Del: Wilmington.
	<10					<10									D.C: Washington.
	<10												<10		Fla: Tampa.
<10							<10							<10	Ga: Atlanta.
					<10								<10		Hawaii: Honolulu.
						<10									Idaho: Idaho Falls.
					14	<10							12	15	Ill: Chicago.
	<10						22								Ind: Indianapolis.
					<10								<10		Iowa: Des Moines.
					<10	<10							<10		Kans: Wichita.
	<10					<10	<10						<10		Ky: Louisville.
													<10		La: New Orleans.
						<10							<10		Maine: Portland.
						<10							<10		Md: Baltimore.
													<10		Mass: Boston.
					20	<10							<10		Mich: Detroit.
					<10	<10							<10		Grand Rapids.
	<10						<10						<10		Minn: Minneapolis.
													<10		Miss: Jackson.
	<10	<10					<10		<10						Mo: Kansas City.
															St. Louis.
		<10	<10										<10		Mont: Helena.
							<10						<10		Nebr: Omaha.
						10									Nev: Las Vegas.
					<10	<10							14		N.H: Manchester.
													<10		N.J: Trenton.
															N. Mex: Albuquerque.
		<10			<10				<10				10		N.Y: Buffalo.
15							<10							<10	New York.
					<10								<10		Syracuse.
					<10								<10		N.C: Charlotte.
						13							<10		N. Dak: Minot.
		12							<10				<10		Ohio: Cincinnati.
						<10									Cleveland.
		<10					<10								Okla: Oklahoma City.
	12								11						Ore: Portland.
						<10			<10						Pa: Philadelphia.
					<10								13		Pittsburgh.
					<10								<10		P.R: San Juan.
						<10							<10		R.I: Providence.
					<10								<10		S.C: Charleston.
	<10						12								S. Dak: Rapid City.
	14				<10										Tenn: Chattanooga.
37						<10									Memphis.
					<10								<10		Tex: Austin.
					<10								<10		Dallas.
					<10								<10		Utah: Salt Lake City.
														<10	Vt: Burlington.
	<10	<10					<10		<10						Va: Norfolk.
													18		Wash: Seattle.
			<10							12					Spokane.
															W. Va: Charleston.
															Wis: Milwaukee.
<10							<10							<10	Wyo: Laramie.

below minimum detectable levels. A similar procedure is used for the network average.

Individual iodine-131 milk concentrations for November are presented in table 2, and are presumed to reflect fallout from the Chinese mainland test of October 27, 1966. For comparative

purposes, distributions of strontium-90 and cesium-137 are presented in tables 3 and 4 for November 1965 and June through November 1966. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations November 1965 and June-November 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965	1966					
		Nov	June	July	Aug	Sept	Oct
Under 10.....	9	9	14	15	21	18	18
10-19.....	43	41	39	40	37	39	41
20-29.....	9	10	9	7	5	6	4
30-39.....	2	3	1	1	0	0	0

Table 4. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations November 1965 and June-November 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965	1966					
		Nov	June	July	Aug	Sept	Oct
Under 50.....	57	56	56	56	61	62	61
50-99.....	5	6	6	6	1	0	2
100-149.....	1	1	1	1	1	1	0

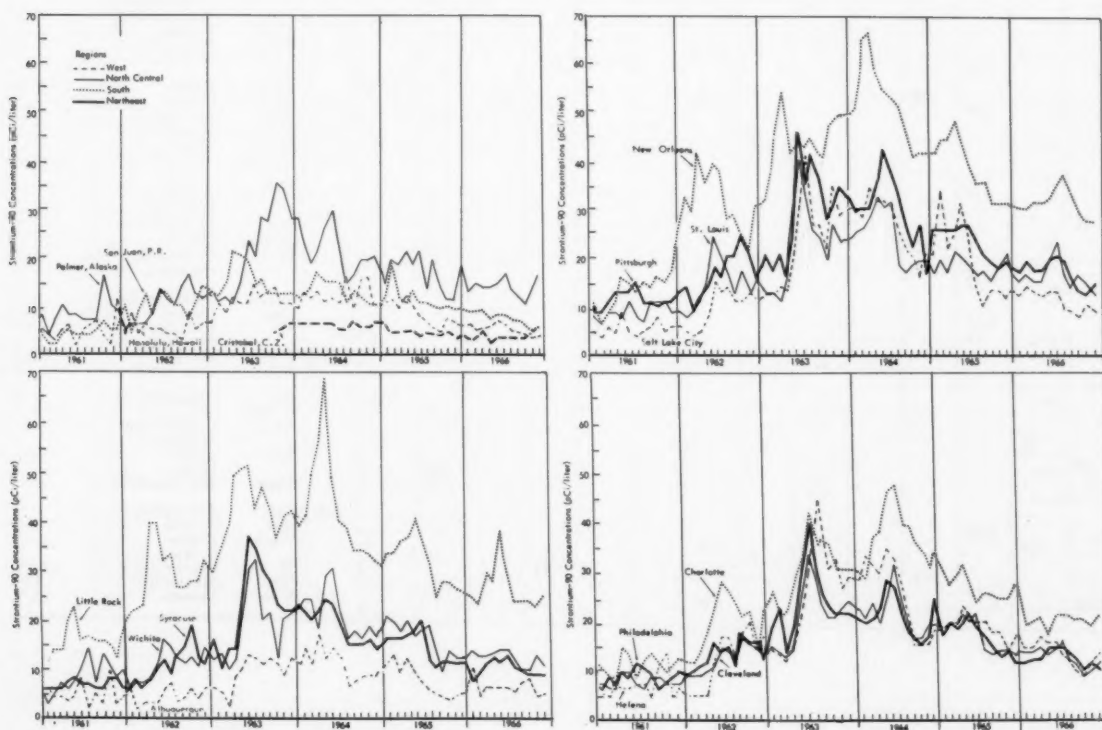


Figure 2. Strontium-90 concentrations in pasteurized milk, 1961-November 1966

2. Canadian Milk Network November 1966¹

*Radiation Protection Division
Department of National Health and Welfare*

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and

potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (2).

The November 1966 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, November 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary.....	1.16	1.4	13.1	27
Edmonton.....	1.12	1.4	11.4	38
Ft. William.....	1.11	1.5	18.0	47
Fredericton.....	1.09	1.5	16.8	44
Halifax.....	1.13	1.5	16.3	37
Montreal.....	1.08	1.5	12.0	37
Ottawa.....	1.13	1.5	8.9	24
Quebec.....	1.08	1.6	17.4	60
Regina.....	1.14	1.5	12.7	24
St. John's, Nfld.....	1.09	1.5	17.8	56
Saskatoon.....	1.12	1.5	13.1	29
Sault Ste. Marie.....	1.07	1.5	15.1	39
Toronto.....	1.12	1.5	7.1	24
Vancouver.....	1.19	1.4	20.6	84
Windsor.....	1.15	1.5	5.8	18
Winnipeg.....	1.11	1.6	9.4	31
Average.....	1.12	1.5	13.5	39

¹ Prepared from December 1966 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.



Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program November 1966

*Pan American Health Organization and
U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO-member countries (figure 4). Results of the milk-sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (3).

Table 6 presents stable potassium, strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 monthly average concentrations for November 1966.

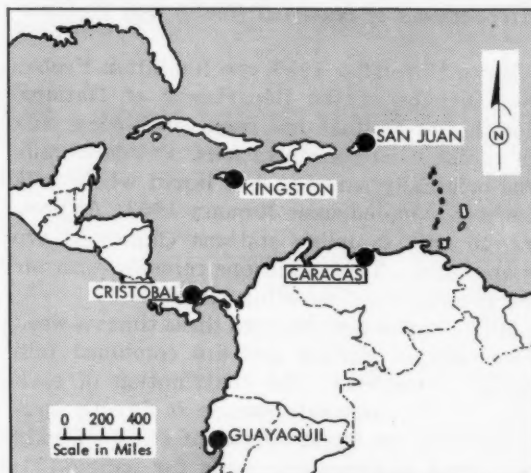


Figure 4. Pan American Milk Sampling Program locations

Table 6. Stable element and radionuclide concentrations in PAHO milk, November 1966

Sampling station	Number of samples	Potassium (g/liter)	Strontium-89 (pCi/liter) ^a	Strontium-90 (pCi/liter)	Iodine-131 ^a (pCi/liter)	Cesium-137 (pCi/liter)	Barium-140 ^a (pCi/liter)
Chile: Santiago-----	5	1.62	15	1	16	4	10
Colombia: Bogota-----	1	1.50	10	3	<10	10	<10
Ecuador: Guayaquil							
Zone 1-----	1	1.53	15	<1	<10	<5	<10
Zone 2-----	1	1.49	15	<1	<10	<5	<10
Jamaica: Kingston-----	NS						
Mandeville-----	1	1.41	5	7	<10	135	20
Montego Bay-----	NS						
Venezuela: Caracas-----	NS						
Canal Zone: Cristobal ^b -----					7	25	
Puerto Rico: San Juan ^b -----					7	15	

^a Data have been corrected for decay to the date of sample collection.

^b For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

NS, no sample collected

4. Radiostrontium in milk² January-June 1966

*Health and Safety Laboratory
U.S. Atomic Energy Commission*

In 1954, the Health and Safety Laboratory began monitoring strontium-90 in liquid whole milk in New York City to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, N.Y. (1954), and at Mandan, N. Dak. (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959. Sampling was terminated at Mandan, N. Dak., and Honolulu, Hawaii, at the end of June 1965.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Perry samples are monthly composites of powdered whole milk for human consumption collected weekly in 5-pound lots from plants in the city. The strontium-90-to-calcium ratios in whole milk are presented in table 7.

² Data summarized from "Fallout Program Quarterly Summary Report, HASL 174," available from Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Va. 22151.

**Table 7. Strontium-90-to-calcium ratios in milk
January-June 1966**

Sampling location	Strontium-90-to-calcium ratios (pCi ⁹⁰ Sr/g Ca)					
	Jan	Feb	Mar	Apr	May	June
New York, N.Y. (liquid whole milk)-----	13.9	14.3	13.0	11.5	13.8	17.0
Perry, N.Y. (powdered whole milk)-----	12.4	11.2	11.0	10.8	11.8	13.9

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January-December 1964	June 1965
January-March 1965	September 1965
April-June 1965	March 1966
July-December 1965	June 1966

REFERENCES:

- (1) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, August 1966. Radiol Health Data Rep 7: 698-701 (December 1966).
- (2) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702-703 (December 1966).
- (3) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704 (December 1966).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have progressed to a state of comprehensive environmental surveillance programs supported by functional radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk sur-

veillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs recently covered in *Radiological Health Data and Reports* include:

<u>State milk network</u>	<u>Period reported</u>	<u>Last presented</u>
Colorado	May 1965-June 1966	October 1966
Connecticut	July-September 1966	February 1967
Florida	July-September 1966	January 1967
Indiana	July-September 1966	February 1967
Michigan	July-September 1966	February 1967
Minnesota	July-September 1966	February 1967
Oklahoma	July-September 1966	January 1967
New York	January-June 1966	November 1966
Pennsylvania	July-September 1966	February 1967
Texas	July-September 1966	January 1967

1. California Milk Network July-September 1966

*Division of Environmental Sanitation
Department of Public Health
State of California*

Surveillance of specific radionuclides in milk is one phase of the California Department of Health program on radiation control. This milk-monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized

milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture as representative of those where milk is consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (1).

Strontium-89 and strontium-90 concentrations are determined radiochemically. Potassium-40, iodine-131, cesium-137, and barium-140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented earlier (2).

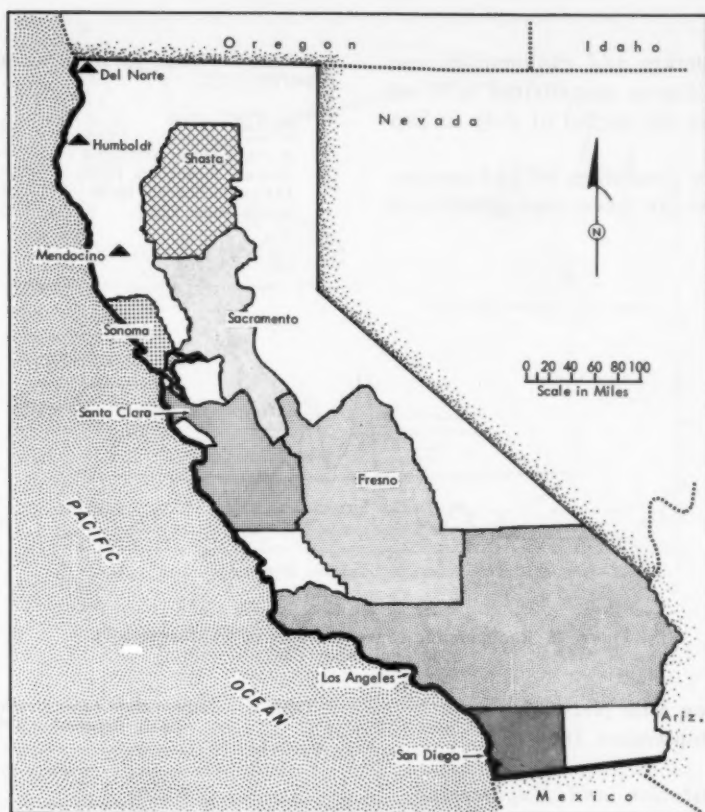


Figure 1. California milksheds

Table 1. Stable elements and radionuclides in California milk, July–September 1966

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
July	NS	1.15	1.22	1.10	1.14	1.19	1.10	1.04	1.12	1.19	1.13
August	1.23	1.09	1.19	1.08	1.21	1.13	1.09	1.11	1.10	1.19	1.14
September	1.22	1.17	1.20	1.09	1.17	1.18	1.13	1.15	1.13	1.24	1.17
Potassium-40 (pCi/liter)											
July	NS	1,190	1,100	1,230	1,220	1,100	1,190	1,250	1,270	1,240	1,200
August	1,220	1,220	1,160	1,230	1,220	1,200	1,190	1,250	1,220	1,310	1,220
September	1,140	1,200	1,170	1,210	1,240	1,170	1,290	1,360	1,250	1,220	1,230
Strontium-89 (pCi/liter)											
July	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	—
August	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	—
September	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	—
Strontium-90 (pCi/liter)											
July	NS	3	6	2	4	4	3	2	5	4	3.6
August	16	5	2	1	1	1	2	3	3	1	3.5
September	9	4	6	3	4	4	3	3	5	5	4.6
Cesium-137 (pCi/liter)											
July	NS	15	11	* 7	* 6	10	7	11	12	9	9.8
August	18	12	* 6	* 6	14	10	ND	6	11	13	10.6
September	15	* 4	10	* 3	* 2	* 5	ND	* 4	9	* 6	6.4

* When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

NS, no sample collected

ND, nondetectable

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period of July to September 1966.

Network average strontium-90 and cesium-137 concentrations are presented graphically in figure 2.

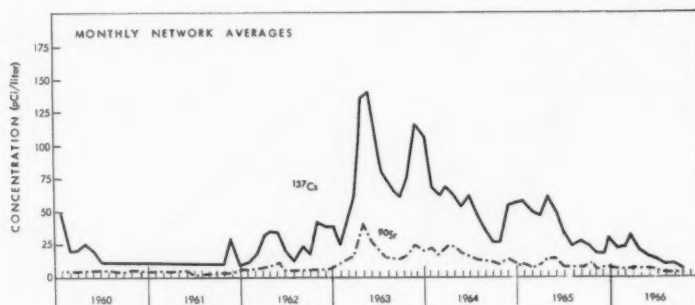


Figure 2. Radionuclide concentrations in California milk 1960-September 1966

2. Oregon Milk Network July-September 1966

*Division of Sanitation and Engineering
Oregon State Board of Health*

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine milk samples are collected at eight major production areas (figure 3), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture, except in the Portland area where weekly samples are collected by the city of Portland. The milk-sampling frequency is accelerated to a weekly basis in areas where iodine-131 concentrations exceed 100 pCi/liter, or where cesium-137 concentrations exceed 500 pCi/liter. Strontium-90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium-90 concentrations are determined using a trichloroacetic acid analytical procedure (5). Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry (4).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
Annual summary 1964	June 1966
Annual summary 1965	June 1966
January-March 1966	September 1966
April-June 1966	December 1966

Table 2. Radionuclide concentrations in Oregon milk July-September 1966

Location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		July	Aug	Sept	July	Aug	Sept
Baker	M	11	NA	6	15	20	20
Coos Bay	M	13	NA	16	15	45	20
Eugene	M	NA	NA	5	30	35	25
Medford	M	8	NA	6	30	40	40
Nyssa	M	14	NA	NS	15	15	NS
Portland composite	W	16	NA	10	27	33	28
Portland local	W	NA	NA	12	44	42	28
Redmond	M	10	NA	8	30	40	20
Tillamook	M	17	NA	12	60	85	40
Average	—	13	14	9	28	39	28

M, sampled monthly
W, sampled weekly
NA, no analysis
NS, no sample collected

Table 2 gives the strontium-90 and cesium-137 concentrations in pasteurized milk from July through September 1966. These data are presented graphically in figure 4. Iodine-131 and barium-140 concentrations remained below minimum detectable levels of 15 pCi/liter.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
Annual summary 1965	June 1966
January-March 1966	September 1966
April-June 1966	December 1966

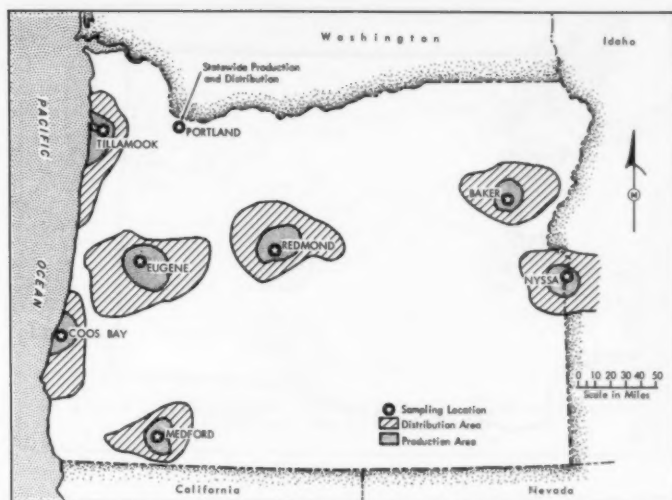


Figure 3. Oregon milk production and distribution areas

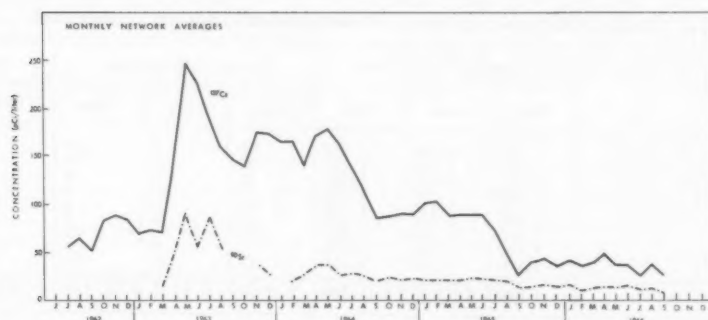


Figure 4. Radionuclide concentrations in Oregon milk network, June 1962-September 1966

3. Washington Milk Network July-September 1966

*Air Sanitation and Radiation Control Section
State of Washington Department of Health*

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk

sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed.

Selected samples are analyzed radiochemically for strontium-90. Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (5).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for July through September 1966. During this period, iodine-131 and barium-140 concentrations remained below minimum detectable levels of 10

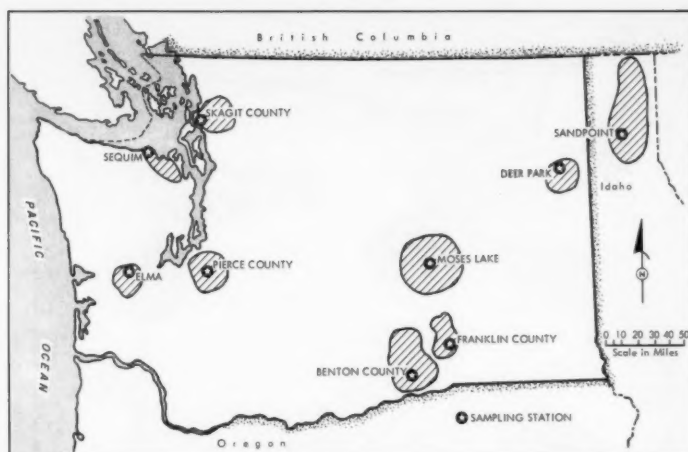


Figure 5. Washington milksheds and sampling locations

Table 3. Radionuclide concentrations in Washington milk, July-September 1966

Sampling location	Potassium-40, pCi/liter			Strontium-90, pCi/liter			Cesium-137, pCi/liter		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Benton County	NS	1,290	NS	NS	6	NS	NS	19	NS
Deer Park	1,300	1,170	1,020	10	11	7	38	39	31
Elma	1,370	1,180	1,340	21	9	7	96	68	49
Franklin County	1,160	NS	1,300	5	NS	4	24	NS	15
Moses Lake	NS	1,240	1,270	NS	6	5	NS	31	<15
Pierce County	1,170	1,190	1,210	15	13	9	73	40	35
Sandpoint	1,300	1,300	1,220	NA	30	22	91	69	46
Sequim	1,210	1,190	1,170	9	6	4	45	31	25
Skagit County	1,170	1,320	1,150	17	15	10	57	39	33
Average	1,240	1,240	1,210	13	12	9	61	42	31

NS, no sample collected
NA, no analysis performed

and 15 pCi/liter, respectively. Monthly average strontium-90 and cesium-137 concentrations are presented graphically in figure 6, to display general trends.

Zinc-65 was identified in the Benton-Franklin area on one occasion during this period (table 4). This nuclide has appeared periodically in this area as a result of the irrigation of

some pasture land with Columbia River water which has been shown to contain this radionuclide.

Table 4. Milk samples in Washington State containing zinc-65

Sampling location	Collection date, 1966	Zinc-65 (pCi/liter)
Franklin County	July 6	<25
Benton County	August 2	<25
Franklin County	September 7	109

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
Annual summaries 1964 and 1965	June 1966
January-March 1966	September 1966
April-June 1966	December 1966

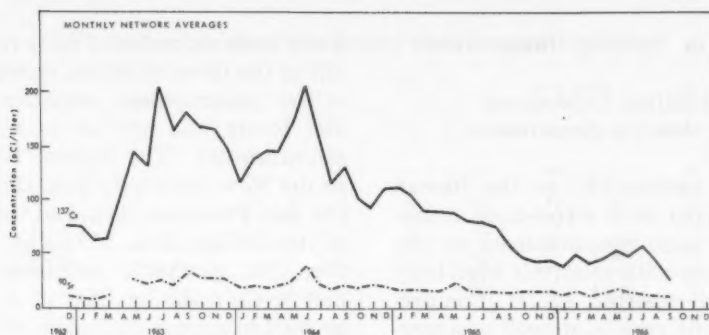


Figure 6. Radionuclide concentrations in Washington milk December 1962-September 1966

REFERENCES

- (1) HESLEP, J. M., and A. C. CORNISH. California milk network and milkshed comparisons, April-June 1963. Radiol Health Data 4:596-599 (December 1963).
- (2) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960-June 1962. Radiol Health Data 4:90-92 (February 1963).
- (3) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J Dairy 43:151-154 (1960).
- (4) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April-June 1965. Radiol Health Data 6:683-684 (December 1965).
- (5) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR AND RADIATION CONTROL SECTION. Washington milk network, January-June 1965. Radiol Health Data 6:619-621 (November 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy

Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

<u>Program</u>	<u>Period reported</u>	<u>Last presented</u>
California Diet	January-April 1965	January 1967
Connecticut Standard Diet	July 1965-June 1966	November 1966
Institutional Diet, PHS	April-June 1966	January 1967
Teenage Diet, FDA	February-November 1965	August 1966
Tri-City Diet, HASL	February-April 1966	December 1966

1. Cesium-137 in Tri-City Diets, 1965¹

Health and Safety Laboratory
U.S. Atomic Energy Commission

The amount of cesium-137 in the human body can be measured with whole-body counters. The results of such measurements on certain Alaskan Eskimos with relatively high body burdens have been reported (1,2). Comprehensive reports of the results of such measurements in the conterminous United States have not appeared in the literature recently. To estimate the average cesium-137 body burdens of people living in large metropolitan areas, the Health and Safety Laboratory (HASL) of the U.S. Atomic Energy Commission has relied on indirect evidence based on estimates of the cesium-137 content in the diet. These estimates of total intake of cesium-137 are in turn based on the analyses of food samples obtained as part of the Tri-City diet studies (3).

In 1961, Brar, Gustafson, and Muniak (4) began measuring by gamma-ray spectrometry the cesium-137 content in foods purchased in Chicago as part of the Tri-City diet program. In late 1964, it was decided that cesium-137 analyses of foods obtained in the Tri-City diet studies might provide additional useful information on the cesium-137 content in the diet in New York and San Francisco, as well as in Chicago. Ashed samples of these foods were analyzed by wet chemistry. Because the foods obtained for the program were ashed at high temperatures, it was likely that some of the cesium-137 in the samples was volatilized before the analyses were performed. To correct for these losses, the average loss for each diet category was computed by comparing the HASL results with those obtained by Brar *et al.* on identical unashed samples purchased in Chicago in 1965. These were averaged and applied to correct the data obtained on the samples from New York City and San Francisco, as well as from Chicago. Results of the analyses

along with estimates of daily intakes of cesium-137 at the three cities are shown in tables 1 to 3.

The geographical variation of cesium-137 diet levels was similar to that observed for strontium-90. The highest levels were found in the New York City diet, the lowest levels in the San Francisco diet, and intermediate levels in the Chicago diet. If this pattern is constant, then the quarterly estimates of cesium-137 diet levels made by Brar *et al.* since 1961 can be used to approximate diet levels in New York City and in San Francisco.

The daily intake of cesium-137 from milk, meat, cereals, fruits, and vegetables, as calculated from the data in tables 1 to 3, along with the percentage intake from these sources, are shown in table 4. As noted by others in previous years, most of the cesium-137 ingested is obtained from meat or dairy products. As pointed out by Gustafson (5), however, the concentration of cesium-137 is decreasing in milk at a greater rate than in other dietary components. Thus the relative importance of milk as a source of cesium-137 in diet is diminishing. This trend, observed in 1965, is assumed to have persisted through 1966.

Body burdens

If it is assumed that the retention of cesium-137 in the body follows a single exponential law, and that 100 percent of the ingested cesium-137 is absorbed (6), then the body burden at any time after ingestion is given by the equation:

$$Q = Q_0 e^{-\lambda t} + \frac{P}{\lambda} (1 - e^{-\lambda t}) \quad (1)$$

where Q is the body burden, λ is the biological decay constant for cesium-137 in the body, and P is the daily intake of cesium-137. If a biological half-life of 3 months (90 days) is assumed, and the estimated daily intakes of cesium-137 at each city are P_1 , P_2 , P_3 , and P_4 for the first, second, third, and fourth quarters of the year, respectively, then one obtains:

$$Q_1 = \frac{Q_0}{2} + \frac{P_1}{2\lambda} = \frac{Q_0}{2} + 65 P_1, \quad (2)$$

or in general,

$$Q_n = \frac{Q_{n-1}}{2} + 65 P_n, \quad (3)$$

¹ Material authored by Mr. J. Rivera from "Fallout Program Quarterly Summary Report, HASL-174, January 1, 1967." Available from the Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Cesium-137 in Tri-City diets, New York City, 1965^a

Food category	Intake (kg/yr)	Feb 1965		May 1965		Nov 1965	
		pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Milk.....	221	107	23,600	109	24,100	35	7,700
Meat.....	73	338	25,000	285	21,000	276	20,000
Poultry.....	17	37	630	40	680	50	850
Fresh fish.....	8	85	700	110	900	174	1,000
Shellfish.....	1	10	10	8	8	9	9
Eggs.....	16	13	210	20	320	20	320
Bakery products.....	37	127	4,700	132	4,900	83	3,100
Whole grain products.....	11	181	2,000	177	1,900	156	1,700
Flour.....	43	95	4,100	105	4,500	48	2,100
Rice.....	3	65	200	50	100	80	200
Macaroni.....	3	194	600	216	600	146	400
Fresh vegetables.....	43	48	2,100	53	3,600	179	7,700
Canned vegetables.....	20	14	280	10	200	9	180
Root vegetables.....	17	9	200	10	200	14	200
Potatoes.....	45	30	1,400	28	1,300	25	1,100
Dried beans.....	3	103	300	135	400	59	200
Fresh fruit.....	68	25	1,700	35	2,400	37	2,500
Canned fruit.....	26	39	1,000	45	1,200	56	1,500
Fruit juices.....	19	35	660	89	1,700	65	1,200
pCi/yr.....			69,390		70,008		51,959
pCi/day.....			190		192		142

^a No analyses for third quarter 1965 (August 1965).

Table 2. Cesium-137 in Tri-City diets, Chicago, 1965

Food category	Intake (kg/yr)	Jan 1965		Apr 1965		July 1965		Oct 1965	
		pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Milk.....	221	72	16,000	95	21,000	40	8,800	43	9,500
Meat.....	73	213	16,000	174	13,000	159	12,000	145	11,000
Poultry.....	17	42	710	41	700	32	540	59	1,000
Fresh fish.....	8	317	3,000	282	2,000	86	700	677	5,000
Shellfish.....	1	9	9	5	5	10	10	15	20
Eggs.....	16	15	240	13	200	15	240	18	290
Bakery products.....	37	136	5,000	127	4,700	109	4,000	110	4,100
Whole grain products.....	11	233	2,600	191	2,100	246	2,700	306	3,400
Flour.....	43	73	3,100	92	4,000	79	3,400	87	3,700
Rice.....	3	136	400	62	200	48	100	120	400
Macaroni.....	3	231	700	172	500	189	600	29	90
Fresh vegetables.....	43	67	2,900	31	1,300	12	520	26	1,100
Canned vegetables.....	20	14	280	6	100	9	200	13	260
Root vegetables.....	17	3	50	6	100	3	50	13	220
Potatoes.....	45	1	40	10	450	4	200	19	860
Dried beans.....	3	39	100	29	90	60	200	99	300
Fresh fruit.....	68	62	4,200	22	1,500	23	1,600	18	1,200
Canned fruit.....	26	40	1,000	23	600	38	990	41	1,100
Fruit juices.....	19	73	1,400	47	900	64	1,200	71	1,300
pCi/yr.....			57,729		53,445		38,050		44,840
pCi/day.....			158		146		104		123

where Q_n is the body burden at the end of the n th quarter and P_n is the daily intake during the n th quarter.

From graphical analysis of the data obtained during 1965, the estimated daily intakes of cesium-137 for each quarter of the year were determined and are given in table 5.

Monthly measurements of the cesium-137 body burdens of two subjects made at HASL during 1965 showed a body burden of about 20 nCi early in the year; this declined to about

15 nCi by the end of the year.² From measurements of Miller, quoted by Gustafson (5), on Argonne National Laboratory personnel, the body burden of Chicago residents at the start of 1965 was about 14 nCi of cesium-137. No estimates are available for body burdens of San Francisco residents at the start of 1965, but a reasonable estimate from the relationship of diet contamination among the three cities

² Personal communication with L. C. Charlton.

Table 3. Cesium-137 in Tri-City diets, San Francisco, 1965

Food category	Intake (kg/yr)	Mar 1965		June 1965		Sept 1965		Dec 1965	
		pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Milk	221	74	16,000	73	16,000	20	4,400	20	4,400
Meat	73	308	22,000	185	14,000	93	6,800	209	15,000
Poultry	17	23	390	39	660	50	850	39	660
Fresh fish	8	56	400	97	800	11	90	61	500
Shellfish	1	8	8	8	8	8	8	35	40
Eggs	16	15	240	4	60	9	100	16	260
Bakery products	37	69	2,600	58	2,100	84	3,100	86	3,200
Whole grain products	11	87	960	50	550	153	1,700	105	1,200
Flour	43	54	2,300	26	1,100	64	2,800	27	1,200
Rice	3	77	200	58	200	111	300	45	100
Macaroni	3	129	400	133	400	224	700	122	400
Fresh vegetables	43	32	1,400	27	1,200	9	400	29	1,200
Canned vegetables	20	6	100	3	60	3	60	6	100
Root vegetables	17	12	200	2	30	6	100	10	170
Potatoes	45	5	200	6	300	15	680	6	300
Dried beans	3	49	100	50	200	49	100	53	200
Fresh fruit	68	16	1,100	14	950	45	3,100	63	4,300
Canned fruit	26	18	470	24	620	32	830	22	570
Fruit juices	19	34	650	27	510	62	1,200	53	1,000
pCi/yr			49,718		39,748		27,318		34,800
pCi/day			136		109		75		95

Table 4. Sources of cesium-137 in Tri-City diets, 1965

Food category	New York City					
	Feb 1965		May 1965		Nov 1965	
	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake
Milk	64	34	67	35	22	15
Meat	72	38	63	33	62	43
Cereals	32	17	32	17	20	14
Fruits	9	5	13	7	14	10
Vegetables	11	6	15	8	26	18
pCi/day	189		191		144	

Food category	Chicago							
	Jan 1965		Apr 1965		July 1965		Oct 1965	
	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake
Milk	44	28	57	39	24	23	26	21
Meat	51	33	44	30	36	35	48	39
Cereals	33	21	32	22	30	29	32	26
Fruits	19	12	9	6	10	10	10	8
Vegetables	9	6	6	4	3	3	7	6
pCi/day	156		146		103		123	

Food category	San Francisco							
	Mar 1965		June 1965		Sept 1965		Dec 1965	
	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake
Milk	44	32	44	41	12	16	12	13
Meat	64	46	41	38	22	29	46	48
Cereals	18	13	12	11	23	31	16	17
Fruits	6	4	5	5	14	19	16	17
Vegetables	6	4	4	4	4	5	6	6
pCi/day	139		108		75		96	

Table 5. Estimated daily intakes of cesium-137, Tri-City diets, by quarters for 1965

City	Daily intakes (pCi/day)			
	First quarter	Second quarter	Third quarter	Fourth quarter
New York City.....	190	180	160	150
Chicago.....	150	125	115	130
San Francisco.....	145	110	85	90

Table 6. Calculated body burdens of cesium-137, by quarters for 1965

City	Body burdens (nCi)				
	Start of 1965	First quarter	Second quarter	Third quarter	Fourth quarter
New York City.....	20	22	23	22	22
Chicago.....	14	17	17	16	16
San Francisco.....	10	14	14	13	13

is about 10 nCi. Substituting these three estimates of Q_0 (20, 14, and 10 nCi for New York City, Chicago, and San Francisco, respectively), and the estimates of P_1 , P_2 , P_3 , and P_4 , the body burdens at the end of each quarter of 1965 for the three cities were calculated using equation (3), and are given in table 6. Based on these calculations it would appear that during 1965 the average cesium-137 body burdens of New York City, Chicago, and San Francisco residents remained virtually constant. It is expected that the decline in cesium-137 diet levels observed during the latter half of 1965 should be reflected in declining body burdens during 1966. It should be kept in mind that the rate of decline for individuals will depend to some extent on the amount of milk that they consume. Individuals normally consuming large amounts of milk will experience a faster decline in body burdens than those consuming less milk.

Summary and conclusion

The best method for determining the cesium-137 content in people is probably by direct measurements using whole-body counters. The next best method is by analyzing foods for cesium-137 by gamma-ray spectrometry or by radiochemistry on wet-ashed samples, and estimating from these analyses the total dietary

intake. Chiefly because of the ready availability of the samples and the obvious need for more information on the subject, HASL has analyzed dry-ashed food samples for cesium-137, attempted to correct the results for losses during ashing by volatilization, and used the results to estimate the total dietary intake. Because the correction factors turned out to be quite variable, this approach was not very satisfactory, and has been discontinued. Despite the shortcomings of the method the following conclusions have been reached, and are thought to be valid:

1. Estimates of the daily intake of cesium-137 made from measurements of the cesium-137 content in foods purchased in New York City, Chicago, and San Francisco during 1965 ranged from 85 pCi/day in San Francisco to 190 pCi/day in New York City. The results of measurements made in one city (e.g., Chicago) can be used to infer the diet levels in the other two cities.

2. Body burdens of cesium-137 can be inferred from dietary intake estimates. At the end of 1965, the body burden of cesium-137 in urban residents of the conterminous United States is estimated to have been about 16 nCi.

3. The major sources of cesium-137 in the diet during 1965 were from meat and milk. The relative importance of milk as a source was decreasing at the end of 1965 and this trend is expected to continue during 1966.

REFERENCES

- (1) PALMER, H. E., W. C. HANSON, and B. J. GRIFFIN. Radioactivity measured in Alaskan natives, 1962-1964. *Science* 147:620 (February 1965).
- (2) HANSON, W. C., and H. E. PALMER. Seasonal cycle of cesium-137 in some Alaskan natives and animals. *Health Physics* 11:1401 (December 1965).
- (3) RIVERA, J., and J. HARLEY. HASL contributions to the study of fallout in food chains, HASL-147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).
- (4) BRAR, S. S., P. F. GUSTAFSON, and S. E. MUNIAK. Cesium-137 in various Chicago foods, HASL-146 and subsequent quarterly reports. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).
- (5) GUSTAFSON, P. F. The relationship between cesium-137 in man and his diet in the Chicago area, HASL-164. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (October 1, 1965).
- (6) MCGRAW, T. F. The half-time of cesium-137 in man, HASL-164:281-300. Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Va. (October 1, 1965); also summarized in *Radiol Health Data* 6:711-718 (December 1965).

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and of specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values in treated water or dissolved solids fractions of raw surface water with the Public Health Service Drinking Water Standards (1). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4), set the upper limits for approval of a drinking water supply containing radium-

226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence¹ of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

Program	Period reported	Last presented
California Water Sampling Program	July-December 1965	November 1966
Coast Guard Water Sampling Program	1965	November 1966
Colorado River Basin Sampling Network	1962-1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963-June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963-July 1964	October 1965
Minnesota Surface Water Sampling Program	July-December 1965	July 1966
New York Surface Water Sampling Program	June-December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Radiostromtium in Tap Water, HASL	May and July-November 1965	June 1966
Washington Surface Water Sampling Program	July 1964-June 1965	May 1966

REFERENCES

- (1) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).
- (2) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.
- (3) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).
- (4) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, SEPTEMBER 1966

*Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior*

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the analysis for alpha- and beta-ray activity. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged

in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports*.

Data and sampling locations have been published for certain years (1-6); information for other periods is available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the



Figure 1. Sampling locations and associated total beta activity (pCi/liter) for surface waters, September 1966

beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water

Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During September, the following stations showed alpha radioactivity in excess of 15 pCi/liter on either dissolved or suspended solids:

Arkansas River: Coolidge, Kans.

Table 1. Radioactivity in raw surface waters, September 1966

Station	Average beta radioactivity, pCi/liter			Average alpha radioactivity, pCi/liter			Station	Average beta radioactivity, pCi/liter			Average alpha radioactivity, pCi/liter		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							Missouri River:						
Cedar Hill, N. Mex.	1	11	12	<1	2	2	Williston, N. Dak.	2	16	18	0	4	4
Arkansas River:							Bismarck, N. Dak.	1	14	15	0	3	3
Coolidge, Kans.	12	33	45	2	20	22	St. Joseph, Mo.	9	12	21	2	3	5
Ponca City, Okla.	19	17	36	4	1	5	North Platte River:						
Atchafalaya River:							Henry, Nebr.	5	30	35	0	10	10
Morgan City, La.	3	10	13	<1	1	1	Ohio River:						
Big Horn River:							Toronto, Ohio	1	12	13	0	0	0
Hardin, Mont.	3	20	23	1	7	8	Pend Oreille River:						
Chena River:							Albeni Falls Dam,						
Fairbanks, Alaska	<1	3	3	0	0	0	Idaho	1	3	4	0	<1	<1
Clearwater River:							Platte River:						
Lewiston, Idaho	<1	2	2	0	0	0	Plattsmouth, Nebr.	13	16	29	4	2	6
Clinch River:							Rainy River:						
Clinton, Tenn.	1	3	4	0	0	0	Baudette, Minn.	1	10	11	<1	0	<1
Kingston, Tenn.	1	6	7	0	0	0	Red River, North:						
Colorado River:							Grand Forks,						
Loma, Colo.	18	21	39	5	17	22	N. Dak.	2	24	26	0	1	1
Page, Ariz.	0	16	16	0	4	4	Red River, South:						
Parker Dam, Calif.							Alexandria, La.	1	14	15	0	1	1
Aris	0	13	13	0	4	4	Rio Grande:						
Columbia River:							El Paso, Tex.	15	16	31	4	4	8
Wenatchee, Wash.	0	3	3	0	0	0	Laredo, Tex.	200	12	212	47	3	50
Paseo, Wash.	48	318	366	0	0	0	San Joaquin River:						
Clatskanie, Ore.	7	25	32	0	<1	1	Vernalis, Calif.	3	6	9	1	8	9
Connecticut River:							San Juan River:						
Enfield Dam, Conn.	1	4	5	0	0	0	Shiprock, N. Mex.	101	14	115	31	3	34
Coosa River:							Savannah River:						
Rome, Ga.	1	3	4	0	0	0	Port Wentworth,						
Cumberland River:							Ga.	6	23	29	0	0	0
Cheatham Lock,							Snake River:						
Tenn.	0	4	4	0	0	0	Payette, Idaho	3	12	15	0	4	4
Delaware River:							Wawawai, Wash.	1	10	11	0	2	2
Philadelphia, Pa.	0	6	6	0	0	0	South Platte River:						
Great Lakes:							Julesburg, Colo.	130	54	184	43	32	75
Duluth, Minn.	0	3	3	0	0	0	Susquehanna River:						
Green River:							Conowingo, Md.	1	6	7	0	0	0
Dutch John, Utah	1	17	18	0	3	3	Tennessee River:						
Hudson River:							Chattanooga, Tenn.	0	6	6	0	0	0
Poughkeepsie, N.Y.	1	7	8	0	0	0	Wabash River:						
Illinois River:							New Harmony, Ind.	2	7	9	0	<1	<1
Peoria, Ill.	3	10	13	0	1	1	Yellowstone River:						
Grafton, Ill.	2	10	12	0	1	1	Sidney, Mont.	24	13	37	7	3	10
Kansas River:							Maximum	200	318	366	47	32	75
DeSoto, Kans.	13	14	27	4	2	6	Minimum	0	2	2	0	0	0
Klamath River:													
Keno, Ore.	<1	7	7	0	0	0							
Maumee River:													
Toledo, Ohio	1	8	9	0	0	0							
Mississippi River:													
St. Paul, Minn.	1	11	12	0	0	0							
E. St. Louis, Ill.	3	11	14	1	1	2							
New Roads, La.	2	12	14	0	2	2							
New Orleans, La.	1	10	11	0	1	1							

* Gross beta activity at this station may not be directly comparable to gross beta activity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

Colorado River: Loma, Colo.
North Platte River: Henry, Nebr.
Rio Grande: Laredo, Tex.
San Juan River: Shiprock, N. Mex.
South Platte River: Julesburg, Colo.

Beta radioactivity in excess of 150 pCi/liter on either dissolved or suspended solids appeared at Pasco, Wash., on the Columbia River; Laredo, Tex., on the Rio Grande; and Julesburg, Colo., on the South Platte River.

REFERENCES

- (1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
- (2) *Ibid.*, 1959 Edition.
- (3) *Ibid.*, 1960 Edition.
- (4) *Ibid.*, 1961 Edition.
- (5) *Ibid.*, 1962 Edition.
- (6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range

trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the results from the above networks was performed by Lockhart and Patterson in 1962 (1). In addition to the programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*.

<u>Network</u>	<u>Period reported</u>	<u>Last presented</u>
HASL Fallout Network	July–December 1965	September 1966

1. Radiation Surveillance Network November 1966

*National Center for Radiological Health
Public Health Service*

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity made by the station operators prior to submission of the samples for laboratory analysis. When high radioactivity levels in air are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (2). A detailed description of the sampling and

Table 1. Gross beta radioactivity in surface air and precipitation, November 1966

Station location		Number of samples		Air surveillance (gross beta radioactivity, pCi/m ³)			Last profile in RHD & R	Precipitation	
		Air	Pptn	Maximum	Minimum	Average *		Total depth (mm)	Total disposition (nCi/m ²)
Ala:	Montgomery	30	5	8.46	<0.10	<0.75	Nov 66	88	<18
Alaska:	Anchorage	30		0.20	<0.10	<0.11	June 66	(*) 11	<2
	Attu Island	16	3	0.49	<0.10	<0.14	Dec 66		
	Fairbanks	30		0.14	<0.10	<0.10	July 66	(*) 52	<12
	Juneau	20	12	0.14	<0.10	<0.10	Jan 67	165	<35
	Kodiak	19	9	0.47	<0.10	<0.13	Feb 67	(*) 6	
	Nome	8		0.83	<0.10	<0.18	Mar 67	(*) 7	
	Pt. Barrow	10		0.10	<0.10	<0.10	Sept 66	(*) 27	<5
	St. Paul Island	27		0.33	<0.10	<0.12	Aug 66	(*) 7	<2
		(*) 25					Oct 66	(*) 60	<13
Ariz:	Phoenix	30		0.50	<0.10	<0.20	Feb 67	(*) 83	<17
Ark:	Little Rock	25	4	13.62	<0.10	<0.93	Dec 66	131	<39
Calif:	Berkeley	19	8	4.54	<0.10	<0.65	Mar 67	113	<23
	Los Angeles	17	3	2.23	<0.10	<0.44	Sept 66	(*) 7	<1
C. Z:	Ancon	13		<0.10	<0.10	<0.10	Feb 67	73	<17
Colo:	Denver	30	2	4.00	<0.10	<0.54	Mar 67	(*) 101	<28
Conn:	Hartford	30	14	0.79	<0.10	<0.27	Jan 67	32	<6
Del:	Dover	20		0.71	<0.10	<0.22	Nov 66	6	13
D. C:	Washington	27	8	1.25	<0.10	<0.26	Aug 66	68	<14
Fla:	Jacksonville	29	4	5.09	<0.10	<0.51	Dec 66	12	<2
	Miami	29	8	11.81	<0.10	<1.02	Jan 67		
Ga:	Atlanta	14		4.18	<0.10	<0.67	Oct 66	(*) 27	<6
Guam:	Agana	30		0.20	<0.10	<0.11	Nov 66	(*) 98	<23
Hawaii:	Honolulu	29	8	3.29	<0.10	<0.25	July 66	138	<31
Idaho:	Boise	29	7	13.63	<0.10	<0.96	July 66	11	<2
Ill:	Springfield	30	6	10.84	<0.10	<0.84	Aug 66	(*) 99	<22
Ind:	Indianapolis	30	10	9.31	<0.10	<0.74	Oct 66	56	<11
Iowa:	Iowa City	29	3	5.55	<0.10	<0.52	Feb 67	(*) 22	<5
Kans:	Topeka	30	3	7.02	<0.10	<0.56	Dec 66	7	5
Ky:	Frankfort	26	9	9.86	<0.10	<0.73	Aug 66		
La:	New Orleans	30	7	5.88	<0.10	<0.82	Aug 66		
Maine:	Augusta	29	11	0.63	<0.10	<0.25	Sept 66	(*) 98	<23
	Presque Isle	19		0.55	<0.10	<0.20	Feb 67	138	<31
Md:	Baltimore	19	3	1.34	<0.10	<0.27	Jan 67	11	<2
	Rockville	18		0.96	<0.10	<0.23	July 66	(*) 99	<22
Mass:	Lawrence	29	13	1.13	<0.10	<0.31	Nov 66	56	<11
	Winchester	27	16	1.31	<0.10	<0.36	Mar 67	159	<32
Mich:	Lansing	30	7	9.87	<0.10	<0.64	July 66	110	<25
Minn:	Minneapolis	20	3	0.21	<0.10	<0.13	Nov 66	26	<5
Miss:	Jackson	29	4	11.97	<0.10	<1.07	Sept 66	7	<1
Mo:	Jefferson City	30	5	11.27	<0.10	<0.97	Oct 66		
Mont:	Helena	27	6	5.90	<0.10	<0.69	June 66	(*) 27	<6
Nebr:	Lincoln	20		2.52	<0.10	<0.24	Oct 66	(*) 98	<23
Nev:	Las Vegas	17		2.11	<0.10	<0.38	Jan 67	138	<31
N.H:	Concord	17		0.97	<0.10	<0.30	Aug 66	11	<2
N.J:	Trenton	30	4	0.95	<0.10	<0.21	Sept 66	(*) 99	<22
N. Mex:	Santa Fe	25	2	0.52	<0.10	<0.20	June 66	56	<11
N.Y:	Albany	19	11	1.22	<0.10	<0.21	Oct 66	(*) 22	<5
	Buffalo	21		3.52	<0.10	<0.43	Feb 67	7	5
	New York	29		0.66	<0.10	<0.20	Mar 67		
N.C:	Gastonia	28	5	1.85	<0.10	<0.36	Feb 67		
N. Dak:	Bismarck	30	2	0.87	<0.10	<0.17	Aug 66		
Ohio:	Cincinnati	12		11.35	<0.10	<1.16	Nov 66	(*) 98	<23
	Columbus	29	9	11.11	<0.10	<0.77	Sept 66	138	<31
	Painesville	30	13	6.92	<0.10	<0.57	Jan 67	11	<2
Okla:	Oklaoma City	29	1	6.22	<0.10	<0.56	July 66	(*) 99	<22
	Ponca City	30		3.16	<0.10	<0.26	Jan 67	56	<11
Ore:	Portland	29	16	2.83	<0.10	<0.23	Oct 66	159	<32
Pa:	Harriaburg	29	3	0.50	<0.10	<0.18	Oct 66	110	<25
P.R:	San Juan	26	7	0.53	<0.10	<0.14	Sept 66	26	<5
R.I:	Providence	29	9	0.74	<0.10	<0.22	July 66	7	<1
S.C:	Columbia	29	6	1.50	<0.10	<0.34	Mar 67		
S. Dak:	Pierre	30	1	2.73	<0.10	<0.33	Feb 67		
Tenn:	Nashville	29	9	9.24	<0.10	<0.65	July 66	67	<14
Tex:	Austin	30	3	11.31	<0.10	<1.08	Nov 66	2	<1
	El Paso	30	1	0.61	<0.10	<0.17	Aug 66	1	<1
Utah:	Salt Lake City	30	6	28.71	<0.10	<2.46	Sept 66	24	<5
Vt:	Barre	30	11	1.12	<0.10	<0.30	Dec 66	40	<9
Va:	Richmond	29	6	0.85	<0.10	<0.25	Dec 66	111	<22
Wash:	Seattle	30	17	0.39	<0.10	<0.13	Dec 66	118	<27
	Sookane	30	3	2.03	<0.10	<0.24	Nov 66	31	<6
W. Va:	Charleston	30	11	3.14	<0.10	<0.38	Mar 67	59	<13
Wis:	Madison	29	3	4.87	<0.10	<0.26	Dec 66	27	<6
Wyo:	Cheyenne	29	3	7.74	<0.10	<0.93	Jan 67	7	<10
Network summary		1,875	363	28.71	<0.10	<0.44		62	<14

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

† No precipitation sample collected

* No report received



Figure 1. Radiation Surveillance Network sampling stations

analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during November 1966. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2. Gross beta radioactivity on air samples collected by most RSN stations increased sharply and remained elevated for several days, beginning about a week to 10 days after the October 27, 1966, nuclear detonations in mainland China and the USSR. Levels reached were comparable to those found after the May 9, 1966, Chinese mainland test. A summary of RSN findings is shown in table 2. The most active sample received was collected on November 5, 1966, at Salt Lake City, Utah, and extrapolated to 28.71 pCi/m³ at the time of collection. Precipitation radioactivity levels were slightly elevated dur-

ing November and fresh fission products were identified in the samples in table 3.

Table 2. Summary of fresh fission product activity observed in RSN air findings

Distribution of activities	Number of samples
1. Fresh fission products, contents confirmed by gamma-ray spectrometry.....	214
2. Less than 1.0 pCi/m ³	97
3. 1.0 to 9.9 pCi/m ³	104
4. 10.0 to 19.9 pCi/m ³	11
5. 20.0 pCi/m ³ or greater.....	2
6. Total number of samples collected.....	1,875

Table 3. Fresh fission product activity observed in precipitation samples

Location	Date 1966	Concentration (pCi/liter)	Deposition (nCi/m ²)
Wyo: Cheyenne.....	Nov. 4	2,500	8.7
Kans: Topeka.....	Nov. 5	3,000	11.9
N. Dak: Bismarck.....	Nov. 7	1,200	4.3
Ind: Indianapolis.....	Nov. 7	900	2.0

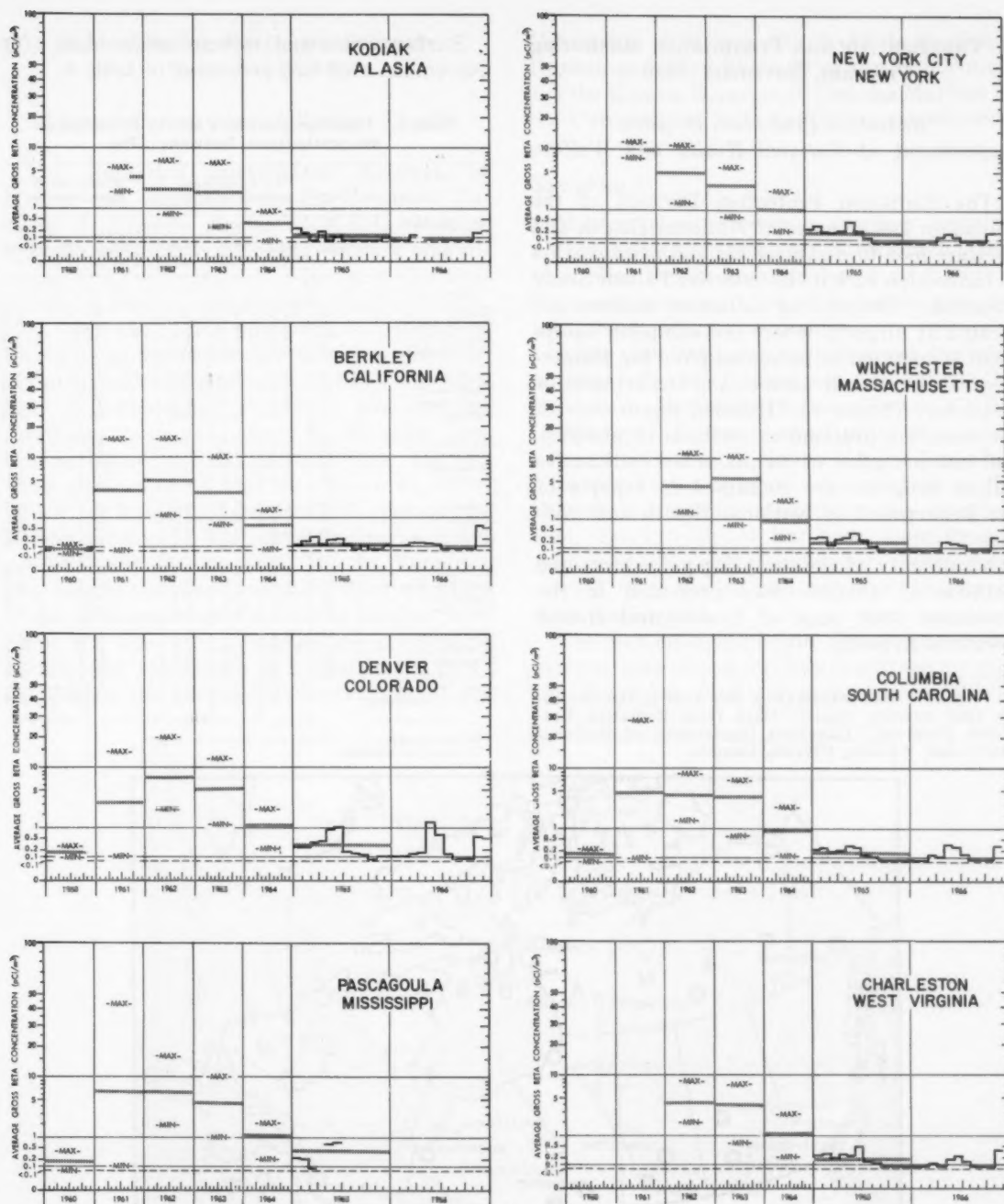


Figure 2. Monthly and yearly profiles of beta radioactivity in air—
Radiation Surveillance Network, 1960-November 1966

2. Canadian Air and Precipitation Monitoring Program, November 1966¹

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport (figure 3). Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (3-7).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports*.

¹ Prepared from information and data in the December 1966 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for November 1966 are presented in table 4.

Table 4. Canadian gross beta activity in surface air and precipitation, November 1966

Station	Number of samples	Air surveillance activity (pCi/m ³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m ²)
Calgary.....	30	11.5	0.1	1.0	45	1.5
Coral Harbour.....	29	0.4	0.0	0.1	47	0.5
Edmonton.....	30	7.5	0.0	0.5	69	1.8
Ft. Churchill.....	30	0.9	0.0	0.2	12	0.5
Ft. William.....	30	0.5	0.0	0.2	21	0.8
Fredericton.....	30	1.0	0.0	0.2	18	1.7
Goose Bay.....	29	0.3	0.0	0.1	17	1.0
Halifax.....	30	3.6	0.0	0.4	65	4.9
Inuvik.....	30	1.0	0.0	0.2	37	0.3
Montreal.....	14	5.5	0.0	0.8	58	5.4
Moosonee.....	30	1.3	0.0	0.2	NS	NS
Ottawa.....	30	4.8	0.0	0.8	42	4.4
Quebec.....	30	1.4	0.0	0.3	16	2.7
Regina.....	30	2.9	0.1	0.4	34	0.8
Resolute.....	29	8.0	0.0	0.6	T	0.2
St. John's, Nfld.....	30	4.3	0.0	0.3	15	1.8
Saskatoon.....	30	4.6	0.1	0.5	75	1.6
Sault Ste. Marie.....	30	1.6	0.0	0.3	27	4.2
Toronto.....	30	7.0	0.0	0.9	54	7.1
Vancouver.....	30	0.8	0.0	0.2	28	4.8
Whitehorse.....	30	0.4	0.0	0.2	31	0.7
Windsor.....	30	17.0	0.0	1.2	44	5.1
Winnipeg.....	30	2.0	0.0	0.2	25	0.7
Yellowknife.....	30	0.6	0.0	0.2	20	0.4
Network summary.....		3.7	0.0	0.4	36	2.3

NS, no sample
T, trace precipitation



Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program November 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new radiation surveillance network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F., Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the

University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day, using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average activity at each station (1).

The maximum, minimum, and average fission product beta concentrations in surface air during November 1966 are presented in table 5.

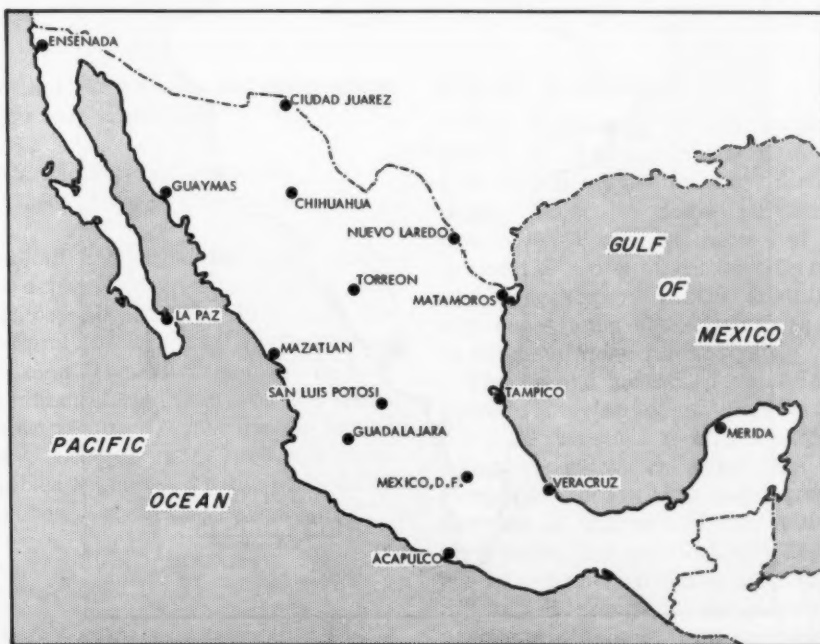


Figure 4. Mexican air sampling station locations

Table 5. Mexican gross beta radioactivity of airborne particulates, November 1966

Station	Number of samples	Gross beta radioactivity, pCi/m ³		
		Maximum	Minimum	Average
Acapulco.....	20	0.1	<0.1	0.1
Chihuahua.....	15	0.2	<0.1	0.1
Ciudad Juárez.....	7	0.2	<0.1	0.1
Ensenada.....	13	0.2	<0.1	0.1
Guadalajara.....	NS			
Guaymas.....	NS			
La Paz.....	8	0.1	<0.1	0.1
Matamoros.....	NS			
Mazatlán.....	11	0.2	0.1	0.1
Merida.....	6	0.2	0.1	0.1
México, D.F.....	11	0.1	<0.1	0.1
Nuevo Laredo.....	NS			
San Luis Potosí.....	NS			
Tampico.....	16	1.5	<0.1	0.2
Torreón.....	11	0.2	<0.1	0.1
Veracruz.....	7	0.4	0.1	0.1

NS, no sample collected, station temporarily shutdown.

4. Pan American Air Sampling Program November 1966

Pan American Health Organization and U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health,



Figure 5. Pan American Air Sampling Program stations

PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station positions are shown in figure 5.

The November 1966 air monitoring results from the participating countries are given in

Table 6. PAHO gross beta radioactivity in surface air, November 1966

Station location	Number of samples	Gross beta radioactivity, pCi/m ³		
		Maximum	Minimum	Average *
Argentina: Buenos Aires..	16	1.49	<0.10	0.50
Chile: Santiago.....	29	1.41	0.11	0.60
Colombia: Bogota.....	19	1.05	<0.10	<0.18
Ecuador: Guayaquil.....	26	5.86	0.26	1.37
Jamaica: Kingston.....	21	1.29	<0.10	<0.17
Peru: Lima.....	2	1.99	1.11	1.55
Venezuela: Caracas.....	20	0.45	<0.10	<0.17
West Indies: Trinidad...	18	0.30	<0.10	<0.12
Pan American summary...	151	5.86	<0.10	<0.58

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more of the samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

table 6. Levels were considerably lower than October levels. During November, fresh fission products were identified in the samples in table 7.

Table 7. Fresh fission product activity observed in PAHO air samples, November 1966

Location	Dates November 1966	Most active sample at time of collection (pCi/m ³)	Date of most active sample
Peru: Lima.....	8, 9 *	1.99	Nov. 8
Chile: Santiago.....	1, 2, 4-14, 16-30 ^b	1.41	Nov. 5
Venezuela: Caracas.....	1-4, 11 *	0.45	Nov. 11
Argentina: Buenos Aires.....	2-12, 15-17 ^d	1.49	Nov. 3
Jamaica: Kingston.....	10-12	1.29	Nov. 10
West Indies: Trinidad.....	10 *	0.30	Nov. 10
Colombia: Bogota.....	2 ^f	1.05	Nov. 2
Ecuador: Guayaquil.....	1-6, 8-19, 23-30 *	5.86	Nov. 2

* No sample received for Nov. 1-7, 10-30

^b No sample received for Nov. 3.

^c No sample received for Nov. 22, 23.

^d No sample received for Nov. 22-30.

^e No sample received for Nov. 18-21.

^f No sample received for Nov. 9-12, 15, 30.

* No sample received for Nov. 7, 20-22.

5. Fallout in the United States and other areas January-June 1966²

*Health and Safety Laboratory
U.S. Atomic Energy Commission*

Monthly fallout deposition rates for strontium-90 are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from all of the active U.S. stations and other selected points in the Western Hemisphere (figure 6) covering the period from January through June 1966 are summarized in tables 8 and 9. All the stations of the 80th Meridian Network are represented.

² The data in this article were taken from Fallout Program Quarterly Summary Report, HASL 174:A-1 to A-169; B-1 to B-22.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless-steel pot with an exposed area of 0.076 m². At the end of the collection period the contents are transferred by careful scrubbing with a rubber spatula, to a polyethylene sample bottle, which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. At the 95-percent confidence level there is no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (1).



Figure 6. HASL fallout sampling stations in the Western Hemisphere

Table 8. Strontium-90 fallout in the United States, HASL, January-June 1966

Sampling location		Type of collection	Fallout deposition, nCi/m ²					
			Jan	Feb	Mar	Apr	May	June
Ala:	Birmingham	pot	0.23	0.47	0.35	0.57	0.18	0.24
Alaska:	Anchorage	column	0.04	0.05	0.01	0.09	0.12	0.07
	Barrow	column	0.05	0.08	0.01	0.02	0.01	0.05
	Cold Bay	column	NS	NS	NS	NS	NS	NS
	Fairbanks	column	0.03	T	0.03	T	0.13	0.12
	Juneau	column	NS	0.49	0.39	0.12	NS	0.39
	Nome	column	0.02	T	NS	NS	0.04	NS
Calif:	W. Los Angeles	pot	0.16	0.05	0.14	0.03	NS	0.06
	San Francisco	column	T	T	0.07	0.07	0.06	0.07
Colo:	Denver	column	T	0.24	0.10	0.24	0.05	NS
Fla:	Coral Gables	pot	0.06	NS	0.11	0.08	0.72	NS
	Miami	column	0.28	0.09	0.15	0.17	0.26	0.69
Hawaii:	Hilo	column	0.11	0.45	0.46	0.47	0.32	0.54
	Honolulu	pot	0.05	0.36	0.24	0.08	0.13	0.11
	Lihue	column	0.14	0.56	0.09	0.31	0.09	0.07
	Mauna Loa	column	T	0.25	0.04	0.04	T	0.01
Ill:	Argonne	pot	0.02	0.12	NS	0.44	0.26	0.19
La:	New Orleans	column	0.26	0.37	0.23	0.25	0.16	0.04
Minn:	International Falls	column	0.03	0.11	0.24	0.19	0.15	0.25
Mo:	Columbia	column	0.03	T	0.18	0.47	0.32	0.40
Mont:	Helena	column	T	0.07	T	0.16	0.17	0.22
N.J:	Westwood	pot	0.14	NS	NS	NS	NS	NS
N.Y:	New York	pot	0.12	0.17	0.28	0.45	0.56	0.16
N. Dak:	Williston	column	0.02	0.01	0.29	0.10	0.24	0.16
Ohio:	Wooster	pot	0.15	0.07	0.31	0.29	0.20	0.42
Okla:	Tulsa	pot	NS	0.22	0.10	0.34	0.55	0.20
Ore:	Medford	column	0.19	0.06	0.20	0.05	0.10	0.05
S.C:	Columbia	column	T	0.23	0.11	0.22	0.42	0.17
S. Dak:	Vermillion	pot	0.03	0.04	0.10	0.39	0.50	0.59
Tex:	Dallas	column	0.13	0.12	0.22	0.46	0.13	0.12
	El Paso	column	0.16	0.41	0.04	0.26	0.11	0.08
	Houston	column	0.09	0.26	0.16	0.30	0.12	0.37
Utah:	Salt Lake City	pot	0.11	0.22	0.16	0.39	0.16	0.11
Va:	Sterling	column	0.08	0.18	0.18	0.29	0.25	0.06
Wash:	Seattle	pot	0.22	0.24	0.46	0.28	0.38	0.15
	Seattle	pot	0.10	0.20	0.32	0.44	0.24	0.13
	Tatoosh Island	column	NS	T	0.99	0.60	0.02	0.21
Wis:	Green Bay	column	0.01	0.14	0.45	0.21	0.18	0.11

NS, no sample reported
T, zero or trace

Other radionuclides

Laboratories at Westwood, N.J., New York, N.Y., and Seattle, Wash., have analyzed monthly precipitation samples for various radionuclides. The amount of precipitation and the monthly deposition rates at each station for iron-55, strontium-90, cerium-144, plutonium-238, plutonium-239, and plutonium-240 are presented in table 10.

REFERENCES

- (1) LOCKHART, L. B., JR., and R. L. PATTERSON, JR. Intercalibration of the major North American networks employed in monitoring airborne fission products. NRL Report 6025. Naval Research Laboratory, Washington, D.C. 20390 (December 1963); summarized in Radiol Health Data 5:12-15 (January 1964).
- (2) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. National Center for Radiological Health, Public Health Service, Rockville, Md. 20852 (distribution by official request).
- (3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).
- (4) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).
- (5) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).
- (6) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).
- (7) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).
- (8) VASQUEZ, M., and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963-1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiológica (en prensa 1966).

Table 9. Strontium-90 fallout in North and South America, HASL, January-June 1966

Sampling location			Fallout deposition, nCi/m ²					
			Jan	Feb	Mar	Apr	May	June
Argentina:	Buenos Aires.....	column	0.22	0.14	0.13	0.07	0.05	0.05
	Formosa.....	column	0.06	0.25	0.10	0.05	0.06	0.02
	Malargue.....	column	NS	0.24	0.11	0.04	0.01	0.06
Bahamas:	Bimini.....	column	NS	NS	NS	NS	0.14	0.08
Bermuda:	Kindley AFB.....	column	0.06	0.38	0.42	0.21	0.10	0.21
Bolivia:	Chacaltaya.....	column	0.07	0.01	T	0.02	NS	NS
	La Paz (city).....	column	0.07	T	0.03	0.02	NS	NS
	La Paz (Ovejuyo).....	column	0.10	0.03	0.02	0.02	NS	NS
Brazil:	Belem.....	column	T	0.16	0.02	0.06	0.05	0.03
	Brasilia.....	pot	T	T	NS	NS	NS	NS
	Itaici Sao Paulo.....	pot	NS	NS	NS	NS	NS	NS
	Nova Friburgo.....	pot	0.08	0.06	0.07	0.09	NS	NS
	Rio de Janeiro.....	column	0.06	0.19	0.26	0.10	NS	NS
	San Jose Dos Campos.....	pot	0.02	T	NS	NS	NS	NS
	Sao Leopoldo.....	pot	0.16	0.14	0.13	0.05	NS	NS
	Trindade Island.....	column	0.03	0.05	T	0.04	0.04	0.04
Canada:	Moosonee.....	column	0.20	0.05	0.10	0.06	0.10	0.02
	Newfoundland.....	column	0.01	T	0.05	NS	NS	NS
Canal Zone:	Miraflores.....	column	0.06	T	0.04	0.27	0.09	T
Chile:	Antofagasta.....	column	0.02	T	0.01	0.01	0.05	T
	I. Alejandro Selkirk.....	column	0.06	T	0.10	0.11	NS	NS
	Easter Island.....	column	0.06	0.06	0.06	0.03	0.05	0.04
	Puerto Montt.....	column	0.06	0.11	0.14	0.09	0.20	0.10
	Punta Arenas.....	column	T	0.05	0.12	0.05	0.03	0.02
	Santiago.....	pot	T	T	T	0.02	T	NS
	Santiago.....	column	0.16	0.21	T	NS	0.02	0.08
Colombia:	Bogota.....	pot	T	0.01	NS	NS	NS	NS
Costa Rica:	Turrialba.....	column	0.10	0.10	0.01	0.07	0.07	0.04
Ecuador:	Guayaquil.....	column	0.06	0.03	T	T	0.03	T
	Quito.....	column	T	0.01	0.02	0.02	0.07	0.07
Greenland:	Thule.....	column	0.01	0.01	0.02	0.02	0.02	0.07
Iceland:	Keflavik.....	column	0.13	0.29	0.18	0.22	0.26	0.26
Mexico:	Mexico City.....	column	0.07	0.16	0.18	T	0.07	T
Peru:	Lima.....	column	0.03	T	0.01	NS	NS	0.02
	Lima.....	column	0.09	0.01	T	0.02	T	T
Puerto Rico:	San Juan.....	column	0.06	0.28	0.15	0.18	0.17	0.07
Venezuela:	Caracas (site 1).....	column	0.15	T	0.02	0.08	T	0.05
	Caracas (site 2).....	column	T	NS	NS	T	0.03	0.03

* Indicates proportioned from originally consolidated data
 NS, no sample reported
 T, zero or trace

Table 10. Radiochemical analyses of precipitation samples at 3 U.S. sites, HASL January-June 1966

	Jan	Feb	Mar	Apr	May	June
Precipitation (cm)						
N.J.: Westwood.....	5.26	9.65	3.38	6.98	10.29	2.11
N.Y.: New York.....	6.68	12.69	2.39	6.83	10.82	2.97
Wash: Seattle.....	12.45	6.25	12.09	5.13	3.40	1.90
Iron-55 (nCi/m ²)						
N.J.: Westwood.....	1.51	1.36	2.95	2.28	4.16	0.89
Wash: Seattle.....	0.02	0.16	5.79	6.14	3.66	1.42
Strontium-90 (nCi/m ²)						
N.J.: Westwood.....	0.14	0.11	0.40	0.43	0.69	0.19
N.Y.: New York.....	0.12	0.17	0.28	0.45	0.56	0.16
Wash: Seattle.....	0.22	0.24	0.46	0.28	0.38	0.15
Cerium-144 (nCi/m ²)						
N.J.: Westwood.....	0.34	0.36	0.69	0.59	1.26	0.40
Wash: Seattle.....	0.42	0.43	0.81	0.58	0.60	0.29
Plutonium-238 (nCi/m ²)						
N.Y.: New York.....	0.00012	0.00030	0.00012	0.00018	0.00057	NS
Wash: Seattle.....	<0.00023	<0.00022	0.00077	0.0018	0.0038	0.012
Plutonium-239-240 (nCi/m ²)						
N.Y.: New York.....	0.0035	0.0032	0.0020	0.0046	0.0045	NS
Wash: Seattle.....	0.0027	0.0013	0.0137	0.0074	0.0086	0.0053

* Data suspect
 NS, no sample reported

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections.

Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

STRONTIUM-90 IN HUMAN BONE, APRIL-JUNE 1966¹

*National Center for Radiological Health
Public Health Service*

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium-90 in measurable amounts has been present in the global environment for more than a decade and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium-90 content to be low and age-independent (1).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is

readily available from older children, but it presents some difficulties in cases of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison of results with British data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the National Center for Radiological Health, at Winchester, Mass. Procedures for sample collection and preparation are explained elsewhere (2). Strontium-90 is measured by TBP extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated from the yttrium-90 radioactivity (3). For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium-90) are analyzed periodically and cross-check analyses are carried out quarterly with the Health and

¹ Period during which death or surgical procedure occurred.

Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium-90 in individual bones from persons dying during the second quarter (April-June) of 1966, along with other pertinent data are presented in table 1 in order of increasing age within each geographic sampling region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development), and per gram of bone (as a rough indication of dose). Two standard deviation counting errors are reported for the ash concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (2-4).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Deaths through 1964	April 1966
First quarter 1965	June 1966
Second quarter 1965	September 1966
Third quarter 1965	October 1966
Fourth quarter 1965	December 1966
First quarter 1966	February 1967

REFERENCES

- (1) RIVERA, J. Strontium-90 in human vertebrae, 1962-1963. *Radiol Health Data* 5:511-513 (October 1964).
- (2) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961-1963. *Radiol Health Data* 5:231-239 (May 1964).
- (3) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64-1. Winchester, Mass. 01890. (April 1964).
- (4) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone, 1962-1965. *Radiol Health Data* 5:620-628 (December 1964).

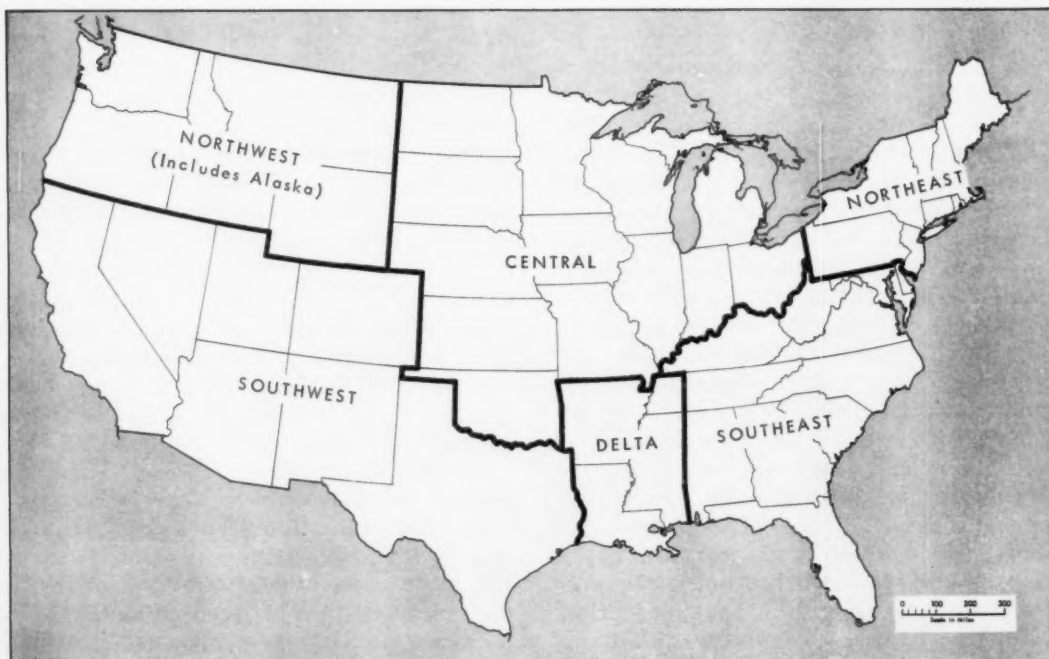


Figure 1. Geographical regions for human bone sampling

Table 1. Strontium-90 in human bone, deaths and surgical procedures during April-June 1966

Sampling region and state of residence	Sex	Bone type ^a	Age at death ^b (years)	Cause of death	Strontium-90, pCi/g of:		
					Ash $\pm 2\sigma$ error	Calcium	Bone
NORTHEAST:							
N.Y.	M	V	1	Ependymoma	1.88 \pm 0.28	5.50	0.12
N.Y.	M	V	1	Myeloblastic leukemia	1.05 \pm 0.14	3.02	0.08
N.Y.	F	V	2	Sarcoma of buttock	1.03 \pm 0.15	2.84	0.09
Mass.	M	V	2	Acute leukemia	1.73 \pm 0.17	5.04	0.13
N.Y.	F	V	4	Respiratory obstruction	1.39 \pm 0.16	3.98	0.11
Pa.	M	V	4	Multiple injuries	0.85 \pm 0.12	2.43	0.07
N.Y.	M	V	5	Lymphoblastic leukemia	0.49 \pm 0.05	1.30	0.06
N.Y.	F	V	6	Cerebral hemorrhage	1.05 \pm 0.13	2.92	0.10
N.Y.	F	V	6	Head injuries	1.37 \pm 0.13	3.79	0.13
R.I.	M	V	6	Tetralogy of Fallot	1.04 \pm 0.08	3.00	0.11
Mass.	M	V	7	Cystic fibrosis	1.47 \pm 0.15	4.21	0.12
N.H.	M	V	8	Multiple injuries	0.82 \pm 0.11	2.22	0.09
N.Y.	M	V	8	Cerebral contusion	1.00 \pm 0.09	2.78	0.10
Mass.	F	V	9	Congenital heart disease	0.65 \pm 0.06	1.82	0.06
N.H.	M	V	9	Acute leukemia	1.19 \pm 0.10	3.28	0.13
N.Y.	M	V	9	Head injuries	0.88 \pm 0.09	2.39	0.08
Mass.	M	V	9	Hodgkins disease	1.37 \pm 0.11	3.64	0.14
N.Y.	F	V	11	Acute leukemia	0.50 \pm 0.07	1.32	0.05
(*)	M	V	11	Agammaglobulinemia	0.47 \pm 0.07	1.31	0.05
N.Y.	M	V	12	Acute leukemia	0.76 \pm 0.09	2.07	0.08
Mass.	M	V	13	Tetralogy of Fallot	1.05 \pm 0.11	2.89	0.09
Maine.	F	V	14	Hemangiosarcoma	0.90 \pm 0.10	2.46	0.10
Mass.	M	V	14	Hodgkin's disease	1.28 \pm 0.08	3.40	0.17
N.Y.	M	V	14	Primary astrocytoma	1.09 \pm 0.09	2.92	0.13
Mass.	F	V	15	Intracranial tumor	1.03 \pm 0.09	2.66	0.12
Mass.	M	V	15	Head injuries	1.12 \pm 0.08	2.96	0.15
N.Y.	M	V	15	Cerebral thrombosis	1.51 \pm 0.10	4.25	0.20
Mass.	M	V	16	Acute leukemia	1.21 \pm 0.15	3.17	0.15
N.H.	M	V	16	Head injuries	1.02 \pm 0.09	2.73	0.14
N.Y.	M	V	17	Acute leukemia	0.86 \pm 0.08	2.24	0.09
R.I.	M	V	17	Cystic fibrosis	0.73 \pm 0.07	1.92	0.08
Mass.	F	V	18	Glioblastoma	0.55 \pm 0.05	1.50	0.05
N.H.	M	V	18	Cerebral laceration	0.93 \pm 0.07	2.32	0.13
Pa.	M	V	18	Thermal burns	0.72 \pm 0.07	1.85	0.10
Conn.	M	V	20	Rupture of aorta	0.68 \pm 0.06	1.76	0.10
N.Y.	F	V	21	Brain stem contusions	0.61 \pm 0.06	1.59	0.10
Mass.	F	V	22	Pancreatic sarcoma	0.65 \pm 0.06	1.67	0.07
N.Y.	M	V	22	Hodgkin's disease	0.81 \pm 0.10	2.25	0.06
Pa.	F	V	24	Multiple injuries	0.53 \pm 0.07	1.37	0.06
N.Y.	M	V	24	Carcinoma of nasopharynx	0.63 \pm 0.10	1.70	0.07
SOUTHEAST:							
Tenn.	M	V	6	Ingestion of gasoline	1.14 \pm 0.18	3.14	0.11
S.C.	M	V	14	Cystic fibrosis	1.13 \pm 0.07	3.28	0.22
CENTRAL:							
Wis.	M	V	0 (5 mo)	Viral encephalitis	1.56 \pm 0.23	4.21	0.14
Ohio	F	V	1	Salicylate poisoning	1.52 \pm 0.16	4.16	0.14
Wis.	M	V	1	Cystic fibrosis	1.04 \pm 0.18	3.00	0.08
(*)	M	V	1	(*)	1.30 \pm 0.16	3.56	0.12
Ohio	M	V	1	Acute meningococemia	1.07 \pm 0.17	2.99	0.10
Ohio	F	V	2	Congenital heart disease	2.39 \pm 0.22	6.65	0.23
Ohio	M	V	2	Hirschsprung's disease	0.70 \pm 0.11	1.90	0.06
Ohio	M	V	2	Gunshot wound of head	1.43 \pm 0.12	3.83	0.23
(*)	M	V	4	(*)	0.84 \pm 0.10	2.48	0.08
(*)	M	V	4	(*)	1.22 \pm 0.12	3.37	0.11
Minn.	F	V	5	Thermal burns	0.87 \pm 0.15	2.48	0.06
Iowa	F	V	5	Thermal burns	1.24 \pm 0.17	3.60	0.09
Wis.	M	V	5	Drowning	0.67 \pm 0.11	1.96	0.05
Ohio	F	V	6	Acute enteritis	0.84 \pm 0.11	2.29	0.08
Minn.	F	V	6	Familial nephrosis	2.59 \pm 0.24	8.10	0.17
(*)	F	V	7	(*)	0.93 \pm 0.08	2.63	0.09
Wis.	M	V	9	Lymphosarcoma	1.06 \pm 0.09	2.87	0.12
Wis.	M	V	9	Cerebral hemorrhage	0.72 \pm 0.07	2.01	0.07
Ohio	F	V	10	Chronic hepatitis	0.49 \pm 0.05	2.13	0.07
Wis.	F	V	11	Lymphocytic leukemia	0.63 \pm 0.06	1.75	0.06
Minn.	F	V	11	Multiple injuries	0.79 \pm 0.07	2.15	0.09
Ohio	M	V	13	Rheumatoid arthritis	0.92 \pm 0.10	2.61	0.07
Minn.	F	V	15	Leukemia	0.72 \pm 0.11	1.97	0.07
Minn.	M	V	15	Bicycle accident	1.28 \pm 0.08	3.35	0.18
Ohio	M	V	18	Multiple fractures	0.94 \pm 0.08	2.41	0.19
Ohio	M	V	18	Laceration of lung	1.06 \pm 0.08	2.78	0.21
Ohio	M	V	18	Fractures of skull	0.66 \pm 0.09	1.76	0.14
Ohio	M	V	18	Injuries of brain	0.94 \pm 0.07	2.43	0.19
Mich.	M	V	22	Multiple injuries	0.58 \pm 0.08	1.56	0.08
Ohio	M	V	22	Cerebral contusions	0.66 \pm 0.06	1.74	0.09
Ohio	F	V	23	Intracranial hemorrhage	1.02 \pm 0.09	2.66	0.19
Ohio	M	V	23	Shotgun wound of head	0.73 \pm 0.06	1.89	0.13
Ohio	M	V	25	Gunshot wounds of body	0.56 \pm 0.06	1.44	0.12

See footnotes at end of table.

Table 1. Strontium-90 in human bone, deaths and surgical procedures during April-June 1966—Continued

Sampling region and state of residence	Sex	Bone type ^a	Age at death ^b (years)	Cause of death	Strontium-90, pCi/g of:		
					Ash $\pm 2\sigma$ error	Calcium	Bone
DELTA:							
La.....	F	V	0(4 mo.)	Congenital heart disease.....	1.84 \pm 0.19	5.44	0.14
La.....	F	V	9	Lobar pneumonia.....	1.09 \pm 0.10	3.04	0.11
La.....	M	V, R	13	Glomerulonephritis.....	1.16 \pm 0.12	3.39	0.12
La.....	F	V	19	Medulloblastoma.....	0.66 \pm 0.07	1.72	0.09
La.....	M	V	24	Diabetes mellitus.....	0.56 \pm 0.06	1.40	0.10
NORTHWEST:							
Alaska.....	F	R	13	(^d).....	1.33 \pm 0.16	3.32	0.45
Alaska.....	M	R	25	(^d).....	0.96 \pm 0.16	2.43	0.37
SOUTHWEST:							
(^c).....	F	S	1	(^c).....	0.41 \pm 0.10	1.45	0.10
Tex.....	M	V	6	Acute leukemia.....	0.78 \pm 0.10	2.23	0.06
Tex.....	F	V	8	Perforated bowel.....	0.51 \pm 0.09	1.40	0.04
Tex.....	F	V	10	Acute leukemia.....	0.64 \pm 0.11	1.78	0.07
Utah.....	M	V	11	Inhalation of glue fumes.....	0.58 \pm 0.09	1.57	0.06
Tex.....	F	V	18	Hypovolemic shock.....	0.67 \pm 0.07	1.91	0.10
(^c).....	F	V	19	(^c).....	0.72 \pm 0.08	1.86	0.09
Colo.....	M	V	23	Traumatic quadriplegia.....	0.50 \pm 0.05	1.32	0.06
Utah.....	M	V	25	Anaphylactic reaction.....	0.57 \pm 0.08	1.48	0.08

^a Type of bone: V, vertebrae; S, sternum; R, rib.^b Age given as of last birthday prior to death.^c Information not yet available.^d Sample obtained from surgical procedure.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."¹

Summaries of data from the environmental radioactivity monitoring reports follow for the Argonne National Laboratory, Atomics International, Feed Materials Production Facilities and the National Reactor Testing Station.

¹ Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

1. Argonne National Laboratory January-June 1966²

*University of Chicago
Lemont, Illinois*

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed are shown in figures 1 and 2.

² Summarized from "Environmental Radioactivity at Argonne National Laboratory, January-June 1966," University of Chicago, Lemont, Ill.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. At one location on the site the filter paper was changed daily; at all other locations the filter papers were changed weekly.

Higher activities on the site are indicative of radioactivity released by Argonne if the differences are greater than the 10 to 20 percent sampling and counting error. The total alpha and beta radioactivities in the weekly samples are summarized in table 1. The alpha radioactivity at all locations was not significant and was in the range found in previous years. The beta radioactivity was due primarily to fission and neutron activation products from nuclear detonations. Until May 15, this radio-

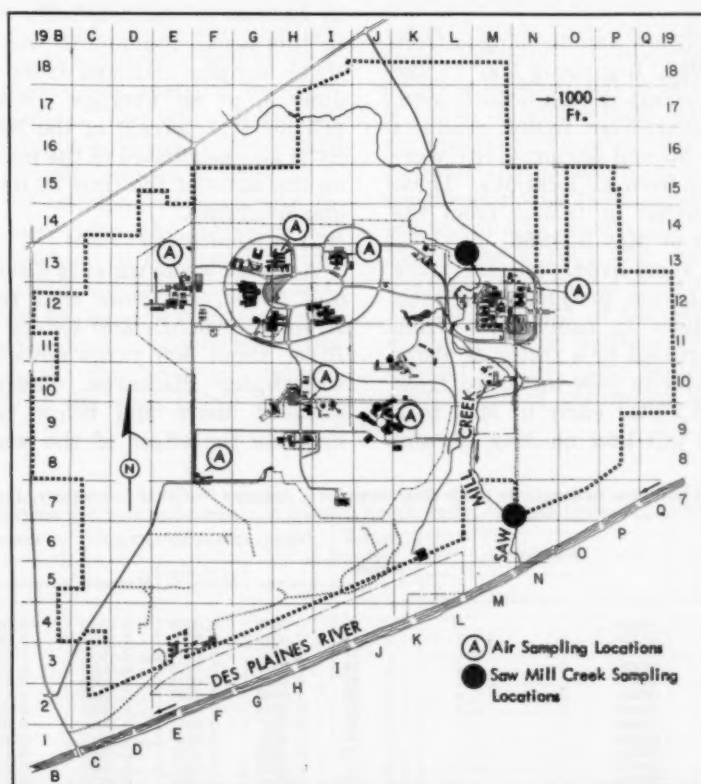


Figure 1. Sampling locations on the site of Argonne National Laboratory

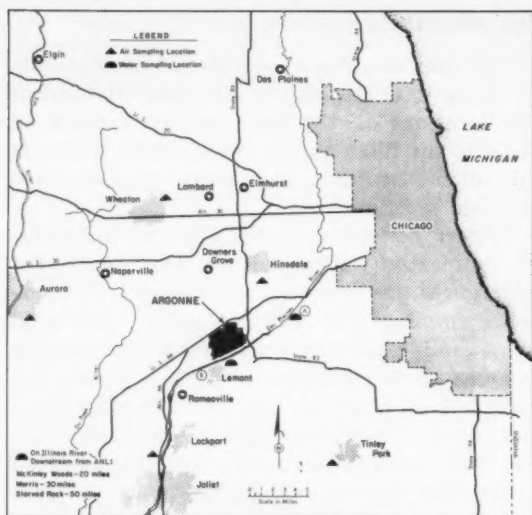


Figure 2. Site location of Argonne National Laboratory (including some offsite sampling stations)

activity was relatively low and unchanged from the last quarter of 1965. Beginning May 15, the beta radioactivity increased significantly and, at the same time, short-lived fission products (such as zirconium-95 and barium-140) were found in air samples from all locations. These changes were attributed to fallout from the mainland China test of May 9, 1966.

The presence of short-lived, and therefore recently produced, fission products was even more readily detectable in rainwater. While the air activities increased by a factor of about three, the radioactivity in rain increased from an average of 30 pCi/liter early in May to a maximum of 13,000 pCi/liter on May 18, and

then decreased to an average of 6,000 pCi/liter during the last half of May and 350 pCi/liter during June.

The average beta radioactivity in air during the first half of 1966 was 0.14 pCi/m³, which was about one-third of the average during the corresponding period in 1965. The similarity between alpha and beta radioactivities onsite and offsite indicates that Argonne did not add significantly to the airborne radioactivity of the environment during this period. The concentrations of specific fission products given in table 2 support this conclusion. Significant releases by Argonne would have been detected in the form of an increase in the onsite activity over the offsite activity.

In addition to the collection of air-filter samples, continuous sampling for gaseous radioiodine with activated charcoal was conducted in the "300 area" on the Argonne site (figure 1) because of the possibility of iodine releases in this area. Iodine-131 was present only in those samples collected from May 15 through June 3, at an average concentration of 0.1 pCi/m³ (0.1 percent of the MPC). This activity is also attributed to the mainland China test on the basis of the time of its appearance and disappearance.

Water monitoring

Argonne waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the wastewater discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the wastewater on the

Table 1. Total alpha and beta radioactivity in air-filter samples ^a, Argonne National Laboratory, January-June 1966

Month 1966	Location	Number of samples	Alpha radioactivity (pCi/m ³)			Beta radioactivity (pCi/m ³)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Onsite	22	0.0036	0.0026	0.0049	0.08	0.04	0.11
	Offsite	18	0.0036	0.0025	0.0049	0.08	0.06	0.10
February	Onsite	21	0.0032	0.0018	0.0043	0.08	0.05	0.11
	Offsite	18	0.0040	0.0025	0.0085	0.09	0.06	0.14
March	Onsite	27	0.0037	0.0015	0.0066	0.10	0.05	0.13
	Offsite	20	0.0039	0.0025	0.0058	0.11	0.07	0.15
April	Onsite	27	0.0038	0.0010	0.0080	0.08	0.02	0.15
	Offsite	23	0.0037	0.0014	0.0061	0.09	0.02	0.15
May	Onsite	25	0.0051	0.0029	0.0077	0.16	0.05	0.38
	Offsite	20	0.0042	0.0022	0.0069	0.17	0.06	0.27
June	Onsite	20	0.0056	0.0037	0.0090	0.29	0.16	0.42
	Offsite	18	0.0046	0.0026	0.0072	0.33	0.19	0.50
Summary	Onsite	142	0.0042	0.0010	0.0090	0.13	0.02	0.42
	Offsite	117	0.0040	0.0014	0.0085	0.15	0.02	0.50

^a These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products. This activity is normally present in the air and disappears within 4 days by radioactive decay.

Table 2. Gamma-ray activity in air-filter samples, Argonne National Laboratory, January-June 1966

Radionuclide	Location	Radioactivity (pCi/m ³)						
		January	February	March	April	May	June	Average
Antimony-125	Onsite	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
	Offsite	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Barium-lanthanum-140	Onsite	<0.01	<0.01	<0.01	<0.01	0.04	0.04	0.02
	Offsite	<0.01	<0.01	<0.01	<0.01	0.04	0.04	0.02
Cerium-144	Onsite	0.01	0.01	0.02	0.02	0.03	0.03	0.02
	Offsite	0.01	0.01	0.02	0.02	0.03	0.03	0.02
Cesium-137	Onsite	0.01	0.01	0.01	0.01	0.02	0.02	0.01
	Offsite	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Ruthenium-rhodium-106	Onsite	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.01
	Offsite	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.01
Zirconium-niobium-95	Onsite	<0.01	<0.01	<0.01	<0.01	0.01	0.03	0.01
	Offsite	<0.01	<0.01	<0.01	<0.01	0.01	0.03	0.01

radioactivity in the creek. The sampling locations are shown in figure 1. Below the wastewater outfall the creek was sampled three times weekly. Equal portions of the three weekly samples were combined into a composite sample and analyzed. The results obtained in this manner represent the average concentrations in the weekly samples. Above the site, samples were collected at weekly intervals, and at least one sample each month was analyzed for each radionuclide of interest. The total alpha and beta radioactivity found in Sawmill Creek during the first half of 1966 is given in table 3.

The concentration of alpha radioactivity in the creek resulting from the presence of Argonne wastewater can be estimated as follows: below the outfall, the natural creek flow supplemented with Argonne wastewater was approximately double the rate of flow above the outfall. Consequently, the average natural alpha radioactivity in the creek below the out-

fall was approximately one-half of the above-site radioactivity or about 1.1 pCi/liter, and the average radioactivity owing to wastewater was about 2.3 pCi/liter. This is similar to the corresponding value for 1965.

The alpha-emitting radionuclides most likely to be present in Argonne waste waters are isotopes of uranium, plutonium, and thorium. The alpha radioactivity resulting from these elements is summarized in table 4. A comparison of these concentrations with the total alpha radioactivity indicates that most of the alpha radioactivity added to the creek in Argonne wastewater was due to uranium. The uranium concentrations above the site were normal. Below the outfall, the wastewater added an average of about 1.4 pCi of uranium per liter, or 0.004 percent of the MPC. Small amounts of plutonium or thorium were present in about one-half of the water samples taken below the outfall. Since plutonium was not detected in

Table 3. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne National Laboratory, January-June 1966

Month 1966	Location *	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Upstream	4	2.2	1.8	2.6	7.1	6.5	7.8
	Downstream	15	2.8	1.3	5.7	20.0	12.1	41.7
February	Upstream	4	2.0	1.7	2.2	9.0	6.3	14.0
	Downstream	12	4.1	3.3	4.8	29.0	24.5	38.2
March	Upstream	5	2.7	1.5	3.9	9.1	7.2	10.4
	Downstream	12	5.4	2.4	12.7	41.6	14.0	99.3
April	Upstream	4	2.1	1.6	2.8	8.7	6.1	12.9
	Downstream	15	2.6	1.3	5.0	15.9	11.5	21.6
May	Upstream	3	2.4	2.0	2.8	14.8	7.8	21.3
	Downstream	12	3.4	2.1	6.5	17.1	12.7	23.6
June	Upstream	5	1.3	0.1	2.3	10.3	8.2	14.0
	Downstream	12	2.2	2.0	2.6	14.3	12.7	17.0
Summary	Upstream	25	2.1	0.1	3.9	9.8	6.1	21.3
	Downstream	78	3.4	1.3	12.7	23.0	11.5	99.3

* Relative sampling location with respect to Argonne wastewater outfall (figure 1)

Table 4. Alpha-emitting elements in Sawmill Creek water, Argonne National Laboratory, January-June 1966

Element	Location *	Number of samples	Concentration, pCi/liter			Percent of MPC	
			Average	Minimum	Maximum	Average	Maximum
Uranium	Upstream	10	1.4	0.8	2.2	0.004	0.005
	Downstream	75	2.1	1.4	5.1	0.005	0.013
Plutonium	Upstream	6	<0.05	<0.05	<0.05	<0.001	<0.001
	Downstream	72	0.42	<0.05	8.0	0.008	0.16
Thorium	Upstream	6	0.05	<0.05	0.12	0.003	0.006
	Downstream	72	0.06	<0.05	0.28	0.003	0.014

* Relative sampling location with respect to Argonne wastewater outfall (figure 1).

the creek above the site, its presence below the outfall was evidently due to the wastewater. Thorium was present at both locations at about the same average concentration, although a few below-outfall samples had a thorium content high enough to attribute its presence to the wastewater. The concentrations of thorium and uranium were similar to those found at the same locations in 1965. The plutonium concentration below the outfall averaged about five times higher than during 1965, but this increased average was due almost entirely to one sample collected during the week of March 23, 1966, which contained 8 pCi of plutonium per liter.

In addition to the natural beta radioactivity in the creek, beta radioactivity from nuclear detonations was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 3 pCi/liter below the site. The Argonne contribution to the total beta radioactivity below the outfall during the first half of 1966 is estimated to be 10 to 15 pCi/liter. The remaining

radioactivity at both locations, about 5 pCi/liter, was attributed to fallout. The concentration of fallout radioactivity was approximately one-half of the 1965 average, while the Argonne contribution to the total beta radioactivity increased by a factor of about two.

Beta radioactivity from Argonne wastewater (in amounts very low compared with the MPC's) was found in some samples of Sawmill Creek water collected below the laboratory outfall. The concentrations of radioactive materials at this location are summarized in table 5. A comparison of these concentrations with those from samples obtained above the outfall indicates that cesium-137, cerium-144, cobalt-60, hydrogen-3, technetium-99, and thorium-protactinium-234 (decay products of uranium-238) can definitely be attributed to Argonne wastewater. Technetium-99 was detected in only one sample. The short-lived fission products, strontium-89 and barium-140, were evidently present as a result of fallout only.

The origin of the strontium-90 below the outfall is difficult to determine since the concentrations were similar at both locations and since this radionuclide is added to below-outfall

Table 5. Beta radioactivity in Sawmill Creek below wastewater outfall, Argonne National Laboratory, January-June 1966

Radionuclide	Number of samples	Concentration (pCi/liter)			Percent of MPC	
		Average	Minimum	Maximum	Average	Maximum
Barium-140	78	<2	<2	<2	<0.007	<0.007
Cerium-144	78	<10	<10	56	<0.1	0.56
Cesium-137	78	1.5	<0.5	2.8	0.008	0.014
Cobalt-58	78	<5	<5	<5	<0.005	<0.005
Cobalt-60	78	2.2	ND	7.2	0.004	0.014
Hydrogen-3	78	* <4	* <4	* 11	<0.13	0.37
Iodine-131	36	<3	<3	<3	<1	<1
Strontium-89	78	<2	<2	2.9	<0.07	0.10
Strontium-90	78	2.1	0.9	4.8	0.7	1.6
Technetium-99	78	<0.5	<0.5	0.6	<0.0002	0.0002
Thorium-protactinium-234	75	1.7	1.1	4.1	0.009	0.021

* Multiply by 10³.
ND, no data reported

water directly from the atmosphere (as fallout) as well as by above-outfall water. However, the Argonne contribution must have been smaller than the fallout contribution.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two rivers is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled weekly, except when the creek was dry, above and below the mouth of Sawmill Creek to determine if the radioactivity in the creek had any effect on the radioactivity in the river. Samples were also obtained at three locations on the Illinois River on May 12 and analyzed for total radioactivity. The average total radioactivity in these two rivers is summarized in table 6 for the first half of 1966.

Table 6. Average radioactivity in Des Plaines and Illinois River water, Argonne National Laboratory, January-June 1966

Location	Concentration, pCi/liter	
	Non-volatile alpha radioactivity	Non-volatile beta radioactivity
Des Plaines River ^a (above Sawmill Creek)...	2.9	14
Des Plaines River ^b (below Sawmill Creek)...	2.2	12
Illinois River ^c	4.1	12

^a Sampled near Route 45, upstream from the mouth of Sawmill Creek.

^b Sampled near Lemont, downstream from the mouth of Sawmill Creek.

^c Average for samples collected at three locations (McKinley Woods State Park, Morris, and Starved Rock State Park) on May 12, 1966.

Dilution of Sawmill Creek water in the Des Plaines River was sufficient to reduce the radioactivity in the creek to undetectable levels in the river. The alpha radioactivity in the Des Plaines River was normal and in the range previously found. The natural beta radioactivity in the Des Plaines River is about 8 pCi/liter and the additional radioactivity, 2 to 25 pCi/liter after the mainland China test, resulted from fallout. The total radioactivity in samples of the Illinois River water collected on May 12

was similar to that found in other bodies of water in the area. No radioactivity originating at Argonne could be detected.

Milk monitoring

Three samples of raw milk produced in the area were collected monthly (except in May, when an additional collection was made after the appearance of fallout from the May 9 nuclear test) and analyzed for the fission products usually present. These fission products were all due to fallout from nuclear detonations and their presence in milk was not related to Argonne operations. The long-lived fission products, strontium-90 and cesium-137 were present in all samples. Their average concentrations were about 35 percent less than during the corresponding period in 1965. The short-lived fission products, strontium-89 and iodine-131, were not detected before May and evidently originated in the mainland China test of May 9, 1966.

Conclusions

Small amounts of several radioactive nuclides were added to Sawmill Creek in Argonne wastewater. The resulting radioactivity concentrations in the creek were well below the MPC's and did not constitute a health hazard. Radioactivity from Argonne operations was not found at any other location off the Argonne site.

Fallout from nuclear test detonations conducted before 1966 was found at locations and in all types of materials examined throughout the first half of the year. Fallout from the atmospheric test detonation conducted by mainland China on May 9 was detected beginning May 15, 1966.

Recent coverage in *Radiological Health Data and Reports*:

Period
January-June 1965
July-December 1965

Issue
March 1966
September 1966

2. Atomics International January-June 1966³

*North American Aviation, Inc.
Canoga Park, California*

Atomics International, a division of North American Aviation, Inc., has been engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants, and for medical, industrial, and scientific applications.

The company world headquarters facility (WHF) is located in Canoga Park, Calif., approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is in Ventura County in the Simi Hills approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in rela-

tion to nearby communities is shown in figure 3.

The basic concept of radiological hazard control at Atomics International requires total containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a check on the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design.

The environs of Atomics International headquarters and the Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical soil, vegetation, and water samples. In addition, continuous environmental air monitoring at the sites provides information concerning particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV-70 filter paper

³ Summarized from "Environmental Monitoring, Semiannual Report, January 1, 1966 to June 30, 1966," Atomics International.

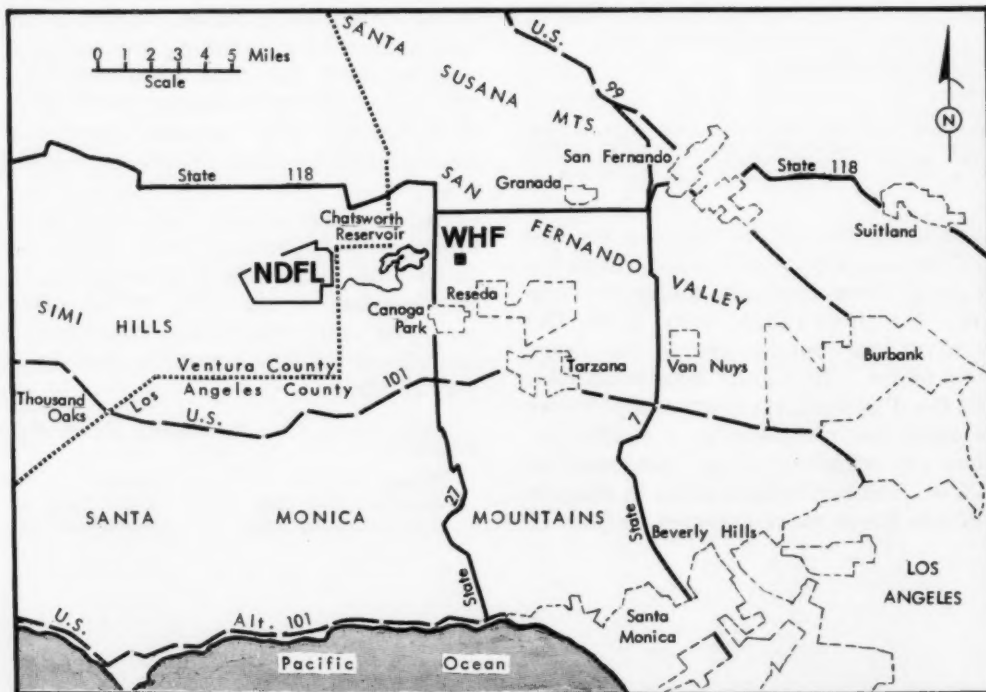


Figure 3. Atomics International facilities and vicinity

which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 20 cubic meters. The average concentration of long lived beta-gamma radioactivity on airborne particulates is presented in table 7 for the calendar year 1965, and for the first half of 1966.

Table 7. Beta-gamma radioactivity of airborne particulates, Atomics International

Location	Calendar year 1965		First half 1966	
	Number of samples	Average radioactivity (pCi/m ³)	Number of samples	Average radioactivity (pCi/m ³)
Headquarters.....	483	0.83	360	0.14
NDFL.....	1,062	0.21	1,178	0.16

Water monitoring

Process-water used at the NDFL is obtained from wells and stored in two 50,000-gallon tanks. Potable water is delivered to the site by a vendor and is not analyzed. Well water is sampled monthly from the supply line at two locations. The average well-water radioactivity is presented in table 8.

Table 8. Well water radioactivity, Atomics International

Radiation	Calendar year 1965		First half 1966	
	Number of samples	Average radioactivity (pCi/liter)	Number of samples	Average radioactivity (pCi/liter)
Alpha.....	24	<0.22	12	0.11
Beta-gamma.....	24	<6.0	12	5.9

Soil, vegetation, and water are sampled monthly at Chatsworth Reservoir, which is operated by the Los Angeles City Department of Water and Power. Soil and vegetation radioactivity for the reservoir are averaged into data presented in tables 9 and 10. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir water supply inlet located on the

Table 9. Radioactivity in the soil, Atomics International

Area	Radiation	Calendar year 1965		First half 1966	
		Number of samples	Average radioactivity (pCi/g)	Number of samples	Average radioactivity (pCi/g)
Onsite.....	Alpha.....	144	0.46	72	<0.39
	Beta-gamma.....	144	36	72	31
Offsite.....	Alpha.....	142	<0.47	24	<0.45
	Beta-gamma.....	142	29	24	25

Table 10. Radioactivity in vegetation, Atomics International

Area	Radiation	Calendar year 1965		First half 1966	
		Number of samples	Average radioactivity (pCi/g ash)	Number of samples	Average radioactivity (pCi/g ash)
Onsite.....	Alpha.....	144	<0.56	72	<0.40
	Beta-gamma.....	144	162	72	176
Offsite.....	Alpha.....	142	0.61	24	<0.39
	Beta-gamma.....	142	138	24	130

north side of the lake. The average radioactivity for both surface and supply water samples is presented in table 11.

Soil and vegetation monitoring

Soil and vegetation are sampled monthly at 24 locations. Twelve sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 12 stations, located within a 10-mile radius of the sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top one-half inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis. Data on radioactivity in soil samples are presented in table 9.

Vegetation samples obtained in the field are of the same plant type wherever possible, generally sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural plants indigenous to the local area. Leaves are stripped from plants and transferred to the

laboratory for analysis. Plant root systems are not routinely sampled. Radioactivity levels in vegetation samples are presented in table 10.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
First half 1965	March 1966
Second half 1965	September 1966

Table 11. Chatsworth Reservoir water radioactivity
Atomics International

Sample	Radiation	Number of samples	Average radioactivity (pCi/liter)	Number of samples	Average radioactivity (pCi/liter)
Lake surface	Alpha.....	11	0.65	6	0.35
	Beta-gamma..	11	8.7	6	6.6
	Alpha.....	12	0.61	6	0.47
	Beta-gamma..	12	<9.1	6	6.9

3. Feed Materials Production Facilities January–December 1965⁴

Mallinckrodt Chemical Works Weldon Spring, Missouri

Environmental monitoring results at the Feed Materials Production Facilities (FMPF) are reported uranium concentrations since natural uranium ore concentrates constitute the primary feed material.

⁴ Summarized from "Semiannual and Annual Off-site Environmental Monitoring Report—1965," Weldon Spring Plant, Mallinckrodt Chemical Works, Uranium Division.

Process chemical wastes and other process residues are permanently retained in storage facilities located at the plant site (figure 4) and at two storage sites (one adjacent to the Lambert-St. Louis Municipal Airport and the other at a quarry near the Missouri River). The plant process-sewer, which carries the remaining water effluent from the operations into the Missouri River, is automatically sampled daily to permit continual measurement of any release of uranium-bearing materials into the river.

Air monitoring

Monthly air samples are collected along the Weldon Spring Plant perimeter (figure 5), at

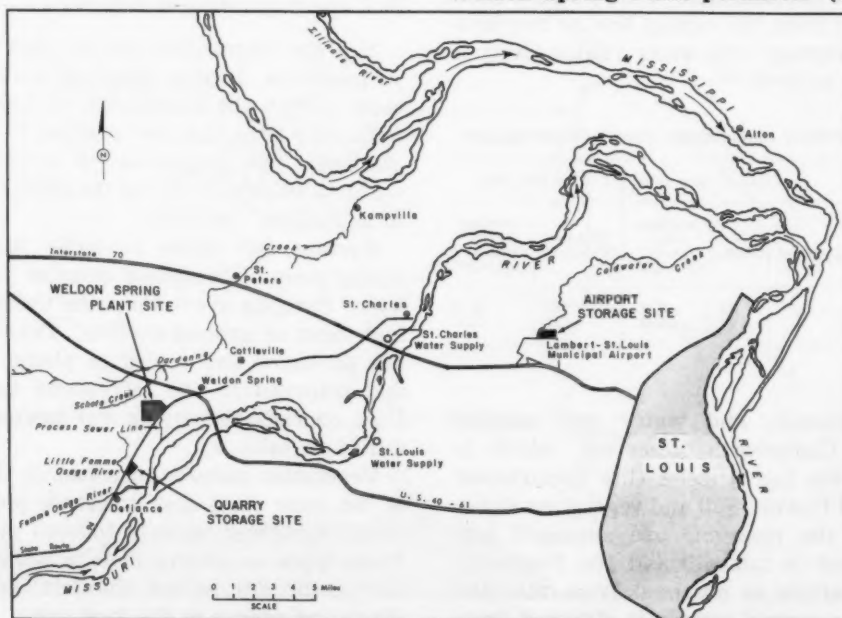


Figure 4. Location of Feed Materials Production Facilities, Weldon Spring

the water plant (2 miles southwest of the plant site), and at the south edge of the AEC quarry (figure 4) by high-volume air-sampling units. Semiannual air samples are also collected at four points on the perimeter of the airport storage site. The uranium concentrations detected in filtered air samples obtained during 1965 at FMPF are summarized in table 12.

**Table 12. Uranium concentrations in air
January-December 1965**

Site	Station location *	Number of samples	Uranium concentration (pCi/m ³)			Average as percent MPC
			Maximum	Minimum	Average	
Plant	1	9	0.38	0.02	0.15	8
	2	10	0.34	0.01	0.06	3
	5	8	0.34	0.03	0.13	6
	6	10	0.10	0.005	0.04	2
	Water plant	5	0.04	<0.01	0.02	1
	South edge	2	0.4	0.3	0.4	20
Quarry	North	2	0.2	0.001	<0.1	<5
	East	2	0.2	0.002	<0.1	<5
	South	2	0.1	0.001	<0.1	<5
	West	2	0.3	0.002	<0.1	<5
Airport	North	2	0.2	0.001	<0.1	<5
	East	2	0.2	0.002	<0.1	<5
	South	2	0.1	0.001	<0.1	<5
	West	2	0.3	0.002	<0.1	<5

* Refer to figures 4 and 5 for site and station locations.

The average uranium concentrations noted in perimeter air samples collected during the second half of 1965 increased slightly from the average obtained during the previous 1965 sampling period. The average uranium concentration in the filtered air samples, with the exception of the AEC quarry, continued to remain below one-tenth of the MPC for air.

Water monitoring

In addition to daily samples from the plant process sewer, periodic offsite water samples are collected from lakes and streams located within the plant's watershed, the Missouri River, and streams near the quarry and airport storage sites at the points indicated in table 13. Uranium concentrations ranged from 1.0 to 4.0 percent of the environmental MPC for samples obtained from the plant-process sewer. The mean uranium concentration for process sewer-water samples was 2.2 percent of the MPC.

Table 13. Uranium concentrations in water, January-December 1965

Sampling locations	Number of samples	Concentration (pCi/liter)			Average as percent MPC
		Maximum	Minimum	Average	
Weldon Spring Plant site:					
Process sewer	214	800	200	440	2.2
Plant offsite sampling points:					
Lake, east of plant	2	<10	<10	<10	<0.1
Lake, north of plant	2	20	<10	10	<0.1
Lake, west of plant	2	<10	<10	<10	<0.1
Lake, south of plant	2	20	<10	15	<0.1
Dardenne Creek, upstream	2	<10	<10	<10	<0.1
Dardenne Creek, Cottleville bridge	2	<10	<10	<10	<0.1
Dardenne Creek, St. Peters' bridge	2	<10	<10	<10	<0.1
Dardenne Creek, Kampville bridge	2	<10	<10	<10	<0.1
Schote Creek, upstream	2	<10	<10	<10	<0.1
Schote Creek, downstream	12	20	<10	20	<0.1
Plant surface drainage, west	12	400	40	500	2.5
Plant surface drainage, north	12	600	10	300	1.5
Missouri River sampling points:					
Upstream at Defiance, Missouri	2	<10	<10	<10	<0.1
Upstream at Femme Osage junction	2	<10	<10	<10	<0.1
U.S. Highway 40-61, south side	2	<10	<10	<10	<0.1
St. Louis city water plant intake	2	<10	<10	<10	<0.1
St. Charles city water plant intake	2	<10	<10	<10	<0.1
Quarry offsite sampling points:					
Tributary of Little Femme Osage, 1/4 mile upstream	2	10	<10	<10	<0.1
Little Femme Osage, 1/4 mile upstream	2	10	<10	<10	<0.1
Little Femme Osage, at quarry discharge culvert	12	10	<10	<10	<0.1
Little Femme Osage, 1/4 mile downstream	2	<10	<10	<10	<0.1
Little Femme Osage, 1 1/4 mile downstream	2	<10	<10	<10	<0.1
Air port offsite sampling points:					
Cold Water Creek, southwest corner of site	2	<10	<10	<10	<0.1
Cold Water Creek, after site pond discharge	2	<10	<10	<10	<0.1
Cold Water Creek, northwest corner of site	2	<10	<10	<10	<0.1

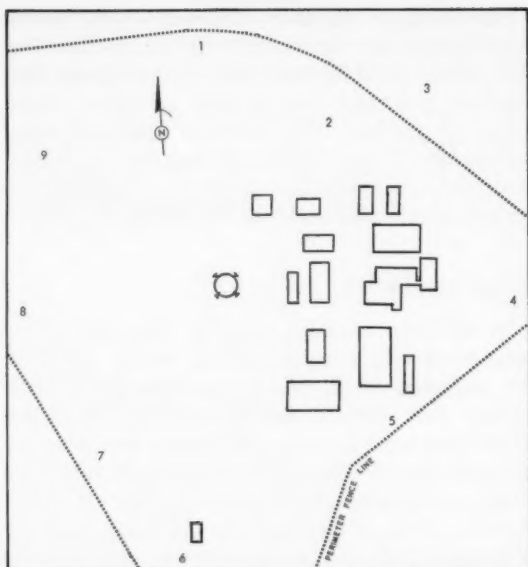


Figure 5. Perimeter air sampling stations
Weldon Spring Plant

Water samples obtained from the Missouri River, with two exceptions, contained less than detectable uranium concentrations both above and below the MCW plant outfall. The exceptions were two samples obtained at the outfall, which averaged uranium concentrations of 0.2 percent of the MPC for uncontrolled areas. Six samples were obtained from the Missouri River sampling station immediately downstream from the outfall. Analysis of these samples yielded nondetectable concentrations of uranium.

Conclusions

The average uranium concentration of all offsite water and air samples collected during the year was 3.6 percent of the MPC, representing a slight increase from the 1964 average of 1.9 percent. The average release of uranium-bearing materials from the MCW Uranium Division was found to be substantially below the MPC for nonoccupational areas for natural uranium. Table 14 summarizes average uranium concentrations and percent of the MPC for samples collected during the first and second quarters and the year 1965.

Table 14. Average uranium concentration of environmental samples, January-December 1965

Source of samples	Average uranium concentrations as percent of nonoccupational MPC (pCi/liter)		
	First half	Second half	Year 1965
Weldon Spring Site:			
Process sewer.....	2	3	2.3
Lakes.....	<0.1	<0.1	<0.1
Drainage ditches.....	0.5	0.3	0.4
Missouri River (below operation)...	<0.1	<0.1	<0.1
Perimeter air.....	4	7	5
Airport site:			
Creeks and ditches.....	<0.1	<0.1	<0.1
Perimeter air.....	0.1	5	4
AEC Quarry site:			
Streams.....	<0.1	<0.1	0.1
Perimeter air.....	—	20	20

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July 1962-December 1963	May 1964
January-December 1964	March 1966

4. National Reactor Testing Station January-June 1966³

*Health and Safety Division
U.S. Atomic Energy Commission
Idaho Falls, Idaho*

Data from the environmental monitoring network on and around the National Reactor Testing Station (NRTS) in eastern Idaho revealed that NRTS operations during the first half of 1966 did not contribute significantly to environmental radiation or radioactivity concentration levels, which remained well below levels defined as thresholds of concern by the Federal Radiation Council (FRC). The Radiation Protection Guides (RPG) and Radioactivity Concentration Guides (RCG) used at the NRTS, which are established in AEC Manual Chapter 0524, are based on FRC recommendations. No significant quantities of radium-226

³ Summarized from "Environmental Monitoring Report No. 18, First and Second Quarter 1966," U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.

or radium-228 have been released to the environs by NRTS operations. The concentrations of radioactivity reported include contributions from all sources. No attempt has been made to separate radioactivity contributed by NRTS operations from that contributed by natural sources of radioactivity or by fallout from weapons debris. Samples of air, water, and milk are collected routinely at stations shown in figure 6. During the growing season, wheat samples are collected routinely at locations shown in figure 6. The results of the analyses performed on these samples are shown in table 15.

Aerial survey

Results obtained from a detailed aerial survey performed over the NRTS in early 1966 confirmed similar measurements obtained in 1959, and again showed no significant change in environmental radiation background that could be attributed to NRTS operations. Radiation measurements were made along parallel courses 1 mile apart at 500 feet altitude. The survey was performed by an AEC contractor who

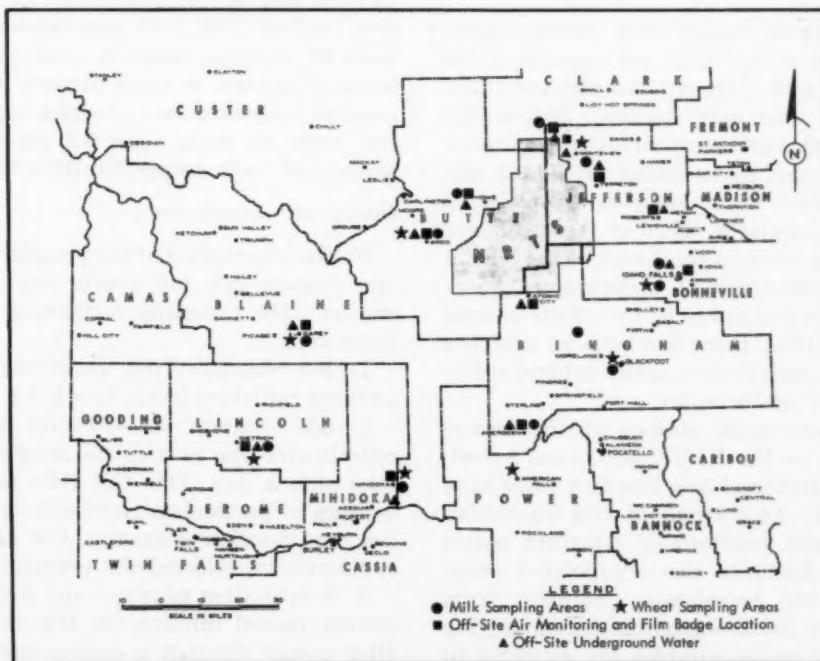


Figure 6. Environmental monitoring stations, National Reactor Testing Station

Table 15. Environmental monitoring program data, NRTS, January-June 1966

Type of sample and units	Number of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum activity of single sample	Average activity per sample	Radioactivity concentration or Radiation Protection Guides
Offsite underground water,* pCi/liter-----	12	Semiannual	Alpha Beta	3 6			100
Onsite production well water, pCi/liter-----	22	Semi-monthly	Alpha Beta	3 6	6 125	<4 <9	3,000 3,000
Offsite air, pCi/m ³ -----	12	Continuous	Beta-gamma Iodine-131	1.6 3.6	32 60	<8 <5	100 100
Offsite milk, pCi/liter-----	12	Monthly	Iodine-131 Strontium-90	20 1.5	30 17	<21 <11	100 200
Offsite area monitoring badges, mR-----	12	Monthly	Gamma	10	<10	<10	170/yr

* Due to changes in sample locations and procedures no data is available for this reporting period.

operates a specially equipped aircraft capable of detecting trace quantities of radioactivity and identifying the material detected. Small variations in the natural background were again noted over varying terrain and were clearly identified with naturally occurring radioactivity in rock and soil formations.

Offsite water monitoring

Low-level liquid wastes from various operating facilities at the NRTS are released to the ground-water table through disposal wells and ponds located near each facility. Before disposal the liquid wastes are carefully monitored at the NRTS and, as an added safeguard, offsite underground water samples are collected and analyzed regularly. Most of these samples are taken from the area southwest of the NRTS, the prevalent direction of underground water flow. Since the beginning of the offsite sample collections in 1952, there has been no evidence of any NRTS contribution to the natural radioactivity in the offsite water.

Through continuing studies of the underground water on the NRTS, additional knowledge of the directional flow and flow rates have been obtained. As a result of this knowledge the number and locations of sampling points have been reduced to those populated areas nearest the site boundaries. Samples from these locations, as shown on the accompanying map, plus the onsite samples are expected to provide adequate information on the underground water leaving the NRTS.

Because of the changes in sampling procedure, no data are available for this reporting period, except for the onsite samples taken at down-gradient locations between the points of discharge and the site boundary.

Onsite water monitoring

Onsite samples were taken from the plant production wells in order to detect and define possible sources of contamination. During the first half of 1966, 215 samples were collected from 22 sampling stations, most on a biweekly basis. Analyses of these samples showed that average concentrations of alpha and beta emitters were no more than 0.2 percent and 0.3 percent of their respective RCG values.

Offsite air monitoring

Normal operations of the present radio telemetry system call for hourly reports by each station. The reporting instruments and functions are:

1. Ion chamber: this instrument measures ambient radiation levels in mR/hr.
2. GM counters: HV-70 filter paper, which collects airborne particulate, is cycled to a GM tube once a day. One GM tube measures the buildup of particulate radioactivity during the day and another measures the decay of the radioactivity collected the previous day.
3. Scintillation counter: air, which has previously passed through the HV-70 particulate filter passes through a carbon cartridge. For surveillance purposes, the radioactivity which is measured hourly is assumed to be iodine-131.

This cartridge remains in place for periods up to 6 weeks.

Results of the data reported from the 15 radiation telemetry stations indicate that the average concentrations of gaseous iodine-131 and particulate radioactivity in the atmosphere were less than 8 percent of the RCG value for the first half of 1966.

Offsite milk monitoring

Routine analyses of iodine-131 and strontium 90 concentrations in milk continued on a monthly basis during the first half of 1966. Of the 68 routine radioiodine analyses, only 3 samples were found to have concentrations greater than 20 pCi/liter. As indicated in table 15, the average iodine-131 levels do not exceed 21 percent of the RCG values. Strontium-90 concentrations in the same 68 samples showed the maximum activity to be 17 pCi/liter, or less than 9 percent of the RCG value with an average value of only 6 percent.

Area monitoring badges

Offsite film badges were collected on a monthly basis during the first half of the year. The

maximum radiation exposure at a single location for any month as measured by film was <10 mR of gamma radiation. The minimum detection limit for the 6 months was 60 mR of gamma radiation, based on six film changes and a detection limit of 10 mR gamma radiation on each film. For the purpose of calculating the maximum exposure, each statistically zero result was assumed to be at the detection limit. The reported maximum is therefore conservatively estimated to be the upper limit of the true exposure at that location. Natural background radiation levels at film badge locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100-150 mR/yr. This indicates that NRTS operations have added no significant radiation to surrounding areas.

Recent coverage in *Radiological Health Data and Reports*:

<u>Period</u>	<u>Issue</u>
January-June 1965	March 1966
July-December and calendar year 1965	September 1966

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, FEBRUARY 1967

During February 1967, three U.S. nuclear tests were reported; on February 8 and February 23, underground nuclear tests of low yield (less than 20 kilotons TNT equivalent) were conducted by the U.S. Atomic Energy Commission at its Nevada test site. Also on February 23, an underground nuclear test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted by the U.S. Atomic Energy Commission at its Nevada test site.

This is the first time since December 1965 that the Atomic Energy Commission has announced two such tests in a single day.

On February 25, the United States recorded seismic signals which originated from the Soviet nuclear-test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the intermediate-yield range (200 kilotons to 1 megaton TNT equivalent).

SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIATION HAZARDS IN URANIUM MINES. *D. A. Holaday.*
Radiological Health Data and Reports, Vol. 8, March 1967, pp. 135-138.

A review of health studies of U.S. uranium miners is presented. The primary radiation hazard in these uranium mines is alpha radiation which is delivered to the lungs by the short-lived daughters of radon. The appearance of lung cancer among uranium miners has been studied and was found to be excessive. The cell-type distribution of these cancers is different from that of the general population. Calculation of radiation dosage to the lungs of miners is difficult.

General dilution ventilation is the primary method of controlling the radiation hazard, but it has limitations. Radiation exposure of uranium miners has gradually been reduced.

KEY WORDS: exposure, lung, lung cancer, mines, miners, radiation hazards, radon daughters, radon-222, smokers, uranium, uranium mines.

ERRATUM

The last equation appearing in the article "Precision and Sensitivity of Gamma Spectrometric Measurements in Milk" (Radiol Health Data Rep 7: 555-559, October 1966) should be amended. The second part of equation (6) on page 556 should read as follows:

☆ U.S. Government Printing Office: 1967-252806/8

THE HISTORY OF THE

REIGN OF KING CHARLES THE FIRST

BY SAMUEL JOHNSON

IN TWO VOLUMES

LONDON

ORDER BLANK FOR RHD&R

**To: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402**

Please enter my subscription for Radiological Health Data and Reports. I am enclosing Money Order ☐ Check ☐ for this subscription. (\$5.00 a year; \$1.50 additional for foreign mailing.)

Please address RHD&R as follows. _____

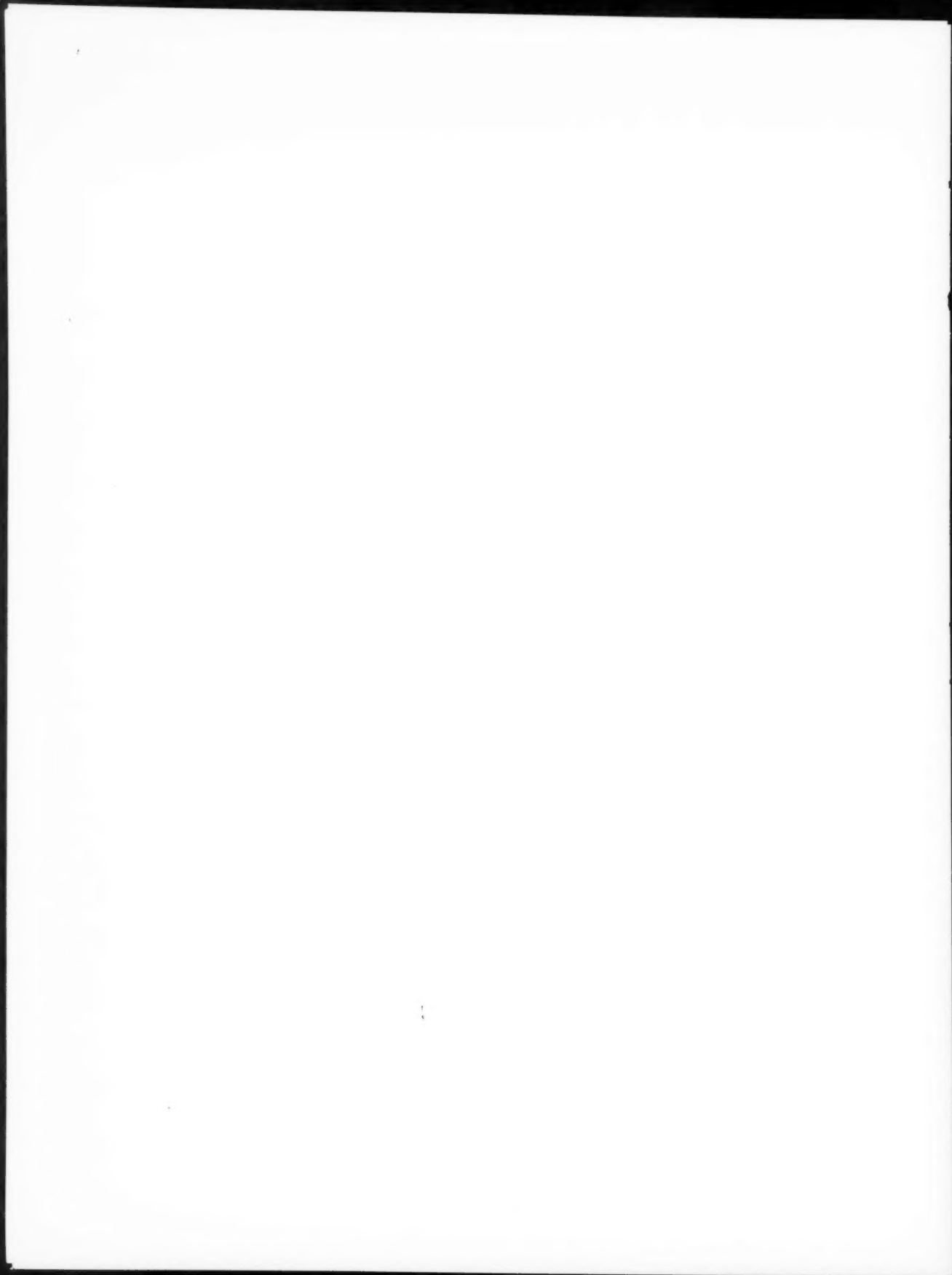
UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C., 1965

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

Subscription price \$5.00 a year, \$1.50 additional for foreign mailing.

Price for a single copy of this issue is 50 cents.

March 1967



INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tēr' a
10^9	giga	G	jī' gə
10^6	mega	M	mīg' a
10^3	kilo	k	kīl' o
10^2	hecto	h	hēk' to
10^1	deka	da	dēk' a
10^{-1}	deci	d	dēs' i
10^{-2}	centi	c	sēn' ti
10^{-3}	milli	m	mīl' i
10^{-6}	micro	μ	mī' kro
10^{-9}	nano	n	nān' o
10^{-12}	pico	p	pē' go
10^{-15}	femto	f	fēm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV.....	billion electron volts.....	GeV
Ci.....	curie.....	3.7×10^{10} dps
cm.....	centimeter(s).....	0.394 inch
cpm.....	counts per minute.....	
dpm.....	disintegrations per minute.....	
dps.....	disintegrations per second.....	
eV.....	electron volt.....	1.6×10^{-12} ergs
g.....	gram(s).....	
GeV.....	giga electron volts.....	1.6×10^{-3} ergs
kg.....	kilogram(s).....	1,000 g = 2.205 lb
km ²	square kilometer(s).....	
kVp.....	kilovolt peak.....	
m ³	cubic meter(s).....	
mA.....	milliampere(s).....	
mCi/mi ²	millicuries per square mile.....	0.386 mCi per square meter (mCi/km ²)
MeV.....	million (mega) electron volts.....	1.6×10^{-7} ergs
mg.....	milligram(s).....	
mi ²	square mile(s).....	
ml.....	milliliter(s).....	
mm.....	millimeter(s).....	
nCi/m.....	nanocuries per square meter.....	2.59 mCi per square mile
pCi.....	picocurie(s).....	10^{-12} curie = 3.22 dpm
R.....	roentgen.....	
rad.....	unit of absorbed radiation dose.....	100 ergs per gram

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

PUBLIC HEALTH SERVICE
WASHINGTON D.C. 20201

OFFICIAL BUSINESS

POSTAGE AND FEES PAID

U.S. DEPARTMENT OF H.E.W.

If you do not desire to continue receiving this publication, please CHECK HERE ☐;
tear off this label and return it to the above address. Your name will then be
promptly removed from the appropriate mailing list.

